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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN, THE NATIONAL IRONFOUNDING EMPLOYERS' FEDERATION, THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Scientific Research.

A recent visit to the National Physical Laboratory and an inspection of the apparatus and experiments in progress there gave one an impression of the extent to which scientific research is being developed in this country under Government auspices. The exhibits on view at the annual inspection in the various departments covered a wide and interesting field. Amongst those which call for special mention are the various wind tunnels which have supplied much valuable data to those engaged in the study of aeronautics; the Alfred Yarrow and the Froude tanks, where experiments are carried out which supply important information on ship design and marine propulsion to naval architects and marine engineers; the testing of glassware and various scientific instruments in the Metrology Department; the X-ray and other apparatus in the Physics Department; the latest apparatus and measuring devices in electrical science, and the various experiments and investigations in progress in engineering and metallurgy.

To the foundryman, and particularly the foundry metallurgist, the most interesting exhibits were to be seen in the departments devoted to the two sciences last mentioned. In the Engineering Department important work is in progress on the relationship between fatigue failures and the crystalline structure of metals, on the corrosion fatigue of metals, and on the resistance of weld and weld metals to repeated loadings. A series of fatigue tests is being carried out on cast irons, both ordinary and austenitic, and at the same time, in order to obtain full information in respect of such tests, growth tests are being conducted on similar irons. In the Metallurgy Department, although there is little direct work in progress of interest to foundrymen, various investigations are being undertaken which in the near future will provide important information to those engaged in both ferrous and non-ferrous foundry practice. Such investigations include determination on the electrical resistivity of molten metals, the solubility of gases in pure iron using both an induction furnace and a molybdenum-wound furnace, the electric melting of aluminium and experiments on the factors controlling the grain size of cast metals.

The impressions derived from the visits to the various departments are that valuable work is in progress in all branches of science and that the results obtained from such work, coupled with the work carried out by the various research associations, the various universities and colleges, technical institutes and private enterprise should be of extreme importance in the future development of industry. In the foundry industry, in which we are particularly interested, such work is not being neglected. In addition to the investigations referred to, investigations are in progress under the auspices of the British Cast Iron and the British Non-Ferrous Metals Research Associations, work is being undertaken by the Technical Committee of the Institute, as well as work carried out by various firms. In this respect we would instance the Papers presented to the Cardiff Conference, which, if the foreign exchange Papers are excluded, are a good illustration of the work carried out by the various interests to which we have referred.

Cylinder Wear.—II.

The extremely interesting report recently published by the Institution of Automobile Engineers, to which reference was made in our last issue, upsets most preconceived notions with respect to cylinder wear. The experiments recorded show that no increase in wear arises from the dilution of lubricating oil by petrol, or by scanty lubrication, or by hot running, that is, high cylinder-wall temperature. Within the limits tested, increased engine load did not result in increased wear, and wear per engine stroke was not increased by increased speed. Cylinder wear appears to be practically independent of running temperature, and stopping and starting tests showed that delayed lubrication and strangling the carburettor do not accelerate wear if the warming-up period be sufficiently rapid.

On the other hand, delayed warming up and scanty lubrication together resulted in a marked increase in cylinder wear, especially below 90 deg. C. It was only below this temperature that increased oil supply reduced wear. The increase of wear is related to the condensation on the cylinder walls of the products of combustion, and water seems to be the prime cause, although organic acids, such as formic and oxalic acids, and inorganic acids, such as sulphuric acid from sulphur in the fuel, and nitric acid, are contributory factors.

The most interesting section shows that the use of austenitic iron, which is well known to be corrosion resisting, reduces wear; a very interesting fact considering that austenitic irons are usually rather soft and have a low Brinell figure.

The maximum wear was at the top of the ring track with a second lower maximum at the bottom. The wear was confined to the ring track and was uniform all round the barrel. The difference due to temperature is indicated by the fact that wear with a cylinder at 50 deg. C. was eight times that at 100 deg. C. This is of great interest to founders, both as such and as car owners, and as the latter our readers will see for themselves what steps can be taken with an existing engine to reduce wear. As founders, the possibility of application of austenitic irons, of which niresist and nicrosilal are examples, for rings, liners, and possibly blocks, is of the greatest possible interest.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

"Internal Chills."

To the Editor of The Foundry Trade Journal.

Sir,—Will you allow me space to issue a word of warning concerning the use of internal chills and all metal inserts in moulds for grey iron?

Unless the inserts are made from metal which is very pure and free from occluded gas, there is a grave danger that the use of these inserts will cause blowholes due to the liberation of gas from the insert when raised to a certain temperature by molten cast iron.

This has not been a personal experience only, but that of many other foundrymen.

I would refer those interested to some experiments made by the undersigned and published in The Foundry Trade Journal of March 18, 1926, under the title of "Gases Evolved from Heated Iron," and also Proceedings of the Institute of British Foundrymen, 1925-1926, Vol. 19, and "Absorbed Gases in Iron and the Creation of Gas Holes in Castings" in The Foundry Trade Journal of June 16, 1927.—Yours, etc.,

Ben Hird.

"Woodcot," Upper Cwmbran,
Nr. Newport, Mon.
July 3, 1933.

Cardiff Works Visit.

Members of the Institute of British Foundrymen, who attended the Cardiff Conference were extremely interested in the works of Messrs. John Williams & Sons (Cardiff), Limited, to which a visit was paid.

The business was founded in 1834 and was purchased in 1844 by Mr. John Edward Williams (the grandfather of Mr. C. Edward Williams, President of the Institute), who advertised in the "Cardiff and Merthyr Guardian" of April 24, 1845, that "he hopes, by strict attention to business and moderate prices, to further merit the patronage and support of a discerning public." That he and his successors have done so is apparent from a very cursory glance at the works. This year, 1933, completes one hundred years of unbroken activity in the City of Cardiff.

The company possesses the following properties:—(1) A steel and iron merchant stock yard, every corner of which is served by electric cranes so that over 100 tons can be assembled out of stock and despatched on the day of receipt of order. Incorporated with the warehouses, with their 3,000 tons of stock, is a comprehensive hardware and engineering supply store; (2) a well-equipped and modern iron foundry laid out for the manufacture of ingot moulds as well as for general jobbing work; (3) a steel constructional shop in which visitors were interested to see a powerful joist cutter which had an unusual double action; (4) a steel window frame factory, which is among the first to manufacture a steel window to fulfil adequately the demands of the architect and the builder. The factory turns out windows of all sizes, dimensions and patterns. Visitors were able to see at work the latest and best methods for galvanising and chromium plating steel window frames; (5) a subsidiary company, Messrs. Emery Bros., Limited, Birmingham, which specialises in the production of high-class non-ferrous rolled strip metal.

The Cardiff works of the company are on the East Moors, where the company owns five private sidings within 500 yards of the Great Western Railway Company's main line, so that the works are situated most conveniently for urgent railway traffic.

The firm is still controlled by the Williams family, who have always taken an interest in their workpeople, as was shown by the institution of the canteen and recreation rooms, and the benevolent fund.

Road and Rail Traffic Bill.

RAILWAYS AND "AGREED RATE."

The Standing Committee of the House of Commons, which is considering the Government's Road and Rail Traffic Bill, has entered upon the consideration of Part II of the Bill, which deals with railway traffic. The first clause of this part of the Bill states that "notwithstanding anything in the Railways Act, 1921," a railway company may make such charges for carriage of goods as may be agreed upon between them and traders, subject to the approval of the Rates Tribunal.

Mr. Lewis Jones moved the omission of the words quoted. He said that he and those associated with him did not approach this part of the Bill in a spirit of antagonism to the objects the Minister of Transport had in view, but he wished to say quite frankly that the trading community generally viewed with great alarm and apprehension the new method of charging rates for conveyance of goods. The essence of the standard charges under the Railways Act, 1921, was that specified rates were to be charged. Parliament, at a time when the railways had a practical monopoly, enacted that the railways must not give undue preference to one trade over another; it was made obligatory on the railways to impose equal charges in like circumstances, and the railways were compelled to record their rates in books open to public inspection. Since the practical monopoly of the railways had gone, traders had no objection to railways being relieved of their statutory obligations concerning that part of their traffic which could be taken from them by road transport.

Mr. Oliver Stanley, Minister of Transport, said the object of the clause was to allow a different kind of rate which would get away from the ton-mile basis. The fixing of the new rates would be subject to a procedure which did not sweep away the existing safeguards, but which would be a good deal simpler and, from the point of view of the railway companies, less stringent. The railway companies had no intention of using the new agreed rate to deal with a case where the old procedure on the ton-mile basis would still be perfectly effective. He added that he proposed later to accept an amendment, which he understood had been agreed to by the interests concerned, to cover the point raised.

The amendment was withdrawn. Later the Minister of Transport accepted, and the Committee agreed to, an amendment to provide that the Tribunal shall not approve an agreed charge if, in their opinion, the object to be secured could be adequately secured by the grant of appropriate exceptional rates under the Railways Act, 1921.

Mr. Stanley stated that the railway companies were prepared to accept the principle that traders should have the right of application to the Tribunal, and of objection with respect to an agreed rate He hoped this would go a long way to remove the fears of traders. He moved an amendment which, he said, would give to the trader a double right under the new procedure: first, the right to object to the agreed rates being given at all; and, secondly, if he did not want to do that, or failed in his objection, to go to the Tribunal himself and have a rate fixed for him.

The amendment was agreed to.

Mr. Culverwell moved an amendment to provide that the Rates Tribunal, when dealing with applications for approval of an agreed charge, should have regard to the "agreed charges made to other traders." He said this was an important consideration for the Tribunal, because it was the rates granted in the Robinson case which had aroused the fears of traders regarding the proposals in the Bill. It was quite true that the Minister had agreed that other traders might apply to the Tribunal to fix rates, but those rates would not necessarily be uniform for all traders carrying the same goods throughout the country.

Mr. Stanley said the effect of the amendment would be that whenever the Rates Tribunal had to deal with an agreed rate, they would have to look up every agreed rate that was ever granted anywhere in the country.

The amendment was negatived.

On the motion that Clause 29 (the discussion of which occupied nearly three sittings of the Committee) stand part of the Bill, several members congratulated Mr. Stanley on the concessions which he had made in the interests of traders, and stated that those would allay the fears which had been aroused when the Bill originally appeared.

The motion was agreed to. The succeeding clauses were considered and added to the Bill, and the Committee adjourned.

Molybdenum in Cast Steel.*

By H. W. Gillett and J. L. Gregg.

The behaviour of molybdenum in cast steel is naturally analogous to its action in similar wrought steels, always, of course, keeping in mind the inherent differences which must exist especially as to ductility and impact in any cast metal, mainly due to absence of work.

High-Temperature Strength.

Of prime importance in these steels is the marked increase in their high-temperature strengths. There is ample indication that simple-annealed or normalized-and-drawn carbon-molybdenum cast steels have virtues for high-temperature service not yet fully appreciated. The most outstanding properties conferred by molybdenum on steel are only noted ordinarily in the quenched and tempered condition. Molybdenum decreases the rate at which the steels must be cooled in order to become martensitic. Accordingly it tends—in proper amount and combination—to produce an air-hardening steel or, in lesser amount and with less of other alloys, one hardenable by a mild air-quench.

It requires a considerable content of molybdenum in a straight carbon-molybdenum steel to produce a high-strength product comparable, by the conventional physical tests, with some other fairly low-alloy steels. Owing to the cost of molybdenum, the plain molybdenum steels are not ordinarily used where static figures alone determine their suitability. It happens, however, that many of the inherent properties conferred by molybdenum on steel are shown as the result of the addition of quite small amounts of it, with great static improvement, if it be used in conjunction with other alloy additions.

Freedom from Melting Losses.

A further feasibility of using molybdenum lies in the fact that the recovery of the metal is very high. Since molten iron will reduce molybdenum from its oxide, there is practically complete freedom from loss when remelting gates and risers. The use of molybdenum introduces no new foundry difficulties and has been said to minimise some of the old ones, such as cracking in the mould.

Molybdenum is compatible with other alloying elements and reduces the amounts of those elements required. Hence, we have the manganese-molybdenum, the chromium-molybdenum, the nickel-molybdenum, and the vanadium-molybdenum steels, or molybdenum steels containing two, three, or even four of other alloying elements, enabling the attainment of combinations of very high mechanical properties which may be sought in quenched and tempered steels.

Heat-treated alloyed-steel castings frequently are used in place of forgings for purposes which few to-day would have thought some years ago could ever be satisfied by castings. Large castings, which then could have been made only in the annealed or normalised condition, are now being quenched successfully in air or oil, and subsequently tempered.

The readiness with which molybdenum fits in with other alloying elements to give steels high in physical properties when quenched and tempered, the added ease and certainty in hardening throughout in quenching produced by molybdenum, and the ability to remove casting strains by a high-temperature draw without softening castings too much, make the element a good friend alike to steel foundrymen and to the user of steel castings.

Cements from Blast-Furnace Slags. — In the "Tonindustrie Zeitung," P. P. Budnikoff and L. Gulinow describe the regeneration of basic blast-furnace slags with calcium sulphate or calcined dolomite for the preparation of cements, and give the properties of the cements manufactured at Russian blast furnaces.

* From a Paper presented at the Annual Convention of the American Foundrymen's Association in Chicago.

New Super Refractory.

DESCRIPTION OF TESTS AND OPERATING RESULTS.

While experimenting in Sweden with the manufacture of low-carbon ferro-chrome in an open arc furnace, the slag formed required such a continuous high temperature to keep it fluid that difficulties were soon experienced with the refractory brickwork. It was then suggested to use this slag for the lining of the furnace, and the results obtained were so successful that steps were immediately taken to develop commercially a super refractory from this material.

The tests on this material have largely been carried out in the open-hearth furnaces of the Mitteldeutsche Stahlwerke at Brandenburg. We append a description of these tests and the operating results. Siemensite is made from chromite, magnesite and bauxite, and has an approximate analysis (per cent.):—Cr_2O_3, 20 to 40; Al_2O_3, 25 to 45; MgO, 18 to 30; other constituents, 8 to 14.

The main constituents, oxide of chromium, alumina and oxide of magnesium, are present in the refractory in the form of spinels. The other constituents, with a small percentage of the main constituents, form silicates. By casting the molten mass into moulds, bricks are made which are subsequently tempered in a continuous furnace in order to eliminate the casting and cooling stresses.

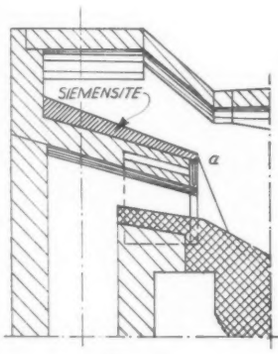


FIG. 1.

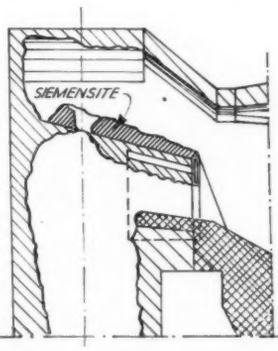


FIG. 2.

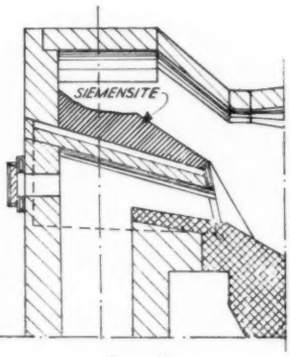


FIG. 3.

The most important characteristics of the Siemensite brick, according to tests so far carried out, are as follow:—(*a*) Refractoriness (fusing point), above Seger cone 42; (*b*) softening under load of 28.9 lbs. per sq. in. (2 kg./cm.²), above 1,800 deg. C.; (*c*) bulk density, including pipe, 3.2 to 3.4; (*d*) heat conductivity, not yet ascertained, but greater than that of magnesite; (*e*) expansion between 0 and 1,200 deg. C., 1.2 to 1.4 per cent.; (*f*) at higher temperatures, about 2 per cent.

The resistance of Siemensite to reaction with acid and basic slags is great at all temperatures. Tests with this material were commenced at the beginning of 1928 in the open-hearth furnaces at the Weber Steelworks in Brandenburg. The conditions in these furnaces are abnormally exacting, as the increase in capacity from 50 tons to 150 tons necessitated a special design of short port construction, the section of which has to remain unchanged during the whole campaign. The scrap process is adopted, carburisation being by means of solid carbon, the charge consisting exclusively of light and rusty bundled scrap with, at times, a large percentage of turnings and scrap iron. The process, therefore, requires a longer high-temperature period, the actual time from tap to tap being 14 to 15 hrs. The consumption of refractories was particularly high at the gas port, wing walls, backwall, stoppings and in the upper parts of the gas and air uptakes. The success obtained by the use of Siemensite can be judged from the fact that to-day the consumption of refractories taken over a long period is 26½ lbs. per ton of steel, this figure including all materials used for the rebuilding of the furnace and repairing flues and gas producers. Certain conditions have to be observed if the use of Siemensite is to be successful, and the following descriptions of tests carried out at Brandenburg are of particular interest in this respect.

Experiments with Gas Ports.

Different refractories for covering the water-cooled frame (*a*) (Fig. 1) had been tried which, however, in every case melted away after a short time in spite of the water-cooling. The result was that the frame became exposed and the working of the furnace was unfavourably influenced. The nose of the port was then made in Siemensite granules, but after a production of 12,000 tons the arch was destroyed due to the silica part collapsing and the Siemensite falling through (Fig. 2). After lengthening the water-cooled frames (Fig. 3) and after covering them with Siemensite granules a life of 680 heats (102,000 tons of steel) was obtained.

It is true that it is the water-cooled frame that prevents the arch from burning away in the first place, but on the other hand it is only due to the use of Siemensite, which is practically indestructible, that such a huge cooling frame may be employed between the gas and air ports without giving rise to excessive cooling losses. The ports and the arch between are now of this construction in all the furnaces and wearing away no longer takes place. The direction of the flame is perfect and assured at all times.

Experiments at the Wing Walls.

The second test with Siemensite granules was made at the wing walls (Fig. 4). Previously these walls were made in magnesite up to six courses (20 in.) above foreplate level and in silica above this. The silica melted and the water-cooled wing-wall frame was exposed causing heavy heat losses and erratic working of the furnace. Cutting of the dolomite banks also occurred due to the running of the silica brickwork. Fettling the bridge bank is one of the most difficult tasks to accomplish and requires a heavy amount of sintered magnesite (Figs. 4 and 5) and can in this furnace be done only after putting the furnace out of commission.

The wing walls were built in Siemensite granules with a slope of about 70 deg. After a production of 8,800 tons these walls had crumbled away to a slope of about 55 deg. Fettling these sloping walls below the roof and near the nose of the gas port proved sufficient. They have now lasted 680 heats (102,000 tons) although a small repair with Siemensite was always necessary after producing 14,000 to 16,000 tons. It was not possible to give a steeper slope to these wing walls without affecting the hearth area.

Siemensite Bricks.

The first experiments of the manufacturer to make a practical brick of Siemensite were not successful. The bricks were very brittle and frequently burst during transport, due to casting stresses. When in use these broken bricks crumbled in the same way as the granules to a slope of 55 deg. With further developments in the manufacture of Siemensite bricks a mechanically-sound cast brick was produced. The wing walls could then be set at an angle to suit the construction of the furnace required and their life was satisfactory. The use of Siemensite in the wing walls in each of the three trials gave superior results to those obtained with other refractories previously used. To-day fettling of the wing walls is not necessary until after 145 to 150 heats (22,000 to 23,000 tons of steel). After this period the wing walls must be patched with about a ton of Siemensite. Fettling at the bridge bank is now hardly ever necessary, so that the total consumption of sintered magnesite is only 0.45 lb. per ton of steel made. Another advantage of constructing the wing walls in Siemensite is that the section of the port is preserved better giving a constant air velocity. The experimental furnaces have, as Fig. 4 shows, very restricted port ends. In most cases this restriction is unnecessary and these wing walls can then be built with a flatter slope. In this case pieces of broken Siemensite brick may be used for these walls without danger of crumbling, thus increasing the economies to be obtained by the use of Siemensite.

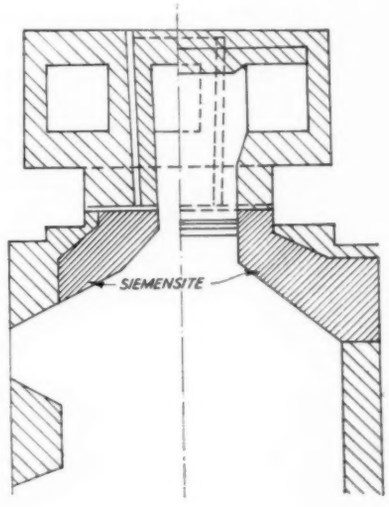


FIG. 4.

Tests in Backwalls.

The first experiment with a backwall made in Siemensite granules was a failure, as this wall was affected by frost during the cold winter of 1928. Another trial followed with furnace No. 4 under better conditions. This backwall in Siemensite granules lasted 235 heats (35,000 tons of steel). Furnaces Nos. 1 and 3 were fitted with similar backwalls in Siemensite granules, but their lives were not as good as that of furnace No. 4, this being probably due to the slope of these backwalls not being so great as that of the latter furnace.

Another trial in furnace No. 3 with a backwall made from the first batch of Siemensite bricks which had already burst in many pieces due to casting stresses was unsuccessful. After one

month's working about 32 sq. ft. above the tapping hole crumbled away. This was fettled during working with dolomite. After 44 working days this backwall was repaired with silica for a length of 15 ft. up to within 2 ft. of the roof skewback, and was repeatedly fettled until the end of the furnace campaign—(22,830 tons of steel). After succeeding in making a sound brick free from stresses, the backwall of furnace No. 4 was made of these bricks. At the end of the furnace campaign (12,000 tons—the furnace had to be put off, due to lack of orders)—the backwall crumbled away above the tapping hole. The cause of this occurrence was probably due to not having fully taken into consideration the expansion of Siemensite bricks, which reaches 2 per cent. The repair required 9.5 tons of Siemensite bricks. The furnace has not been started up since.

As a result of these experiences the backwall of furnace No. 1 was made with 20 tons of Siemensite bricks, and this furnace melted 42,000 tons of steel without any repairs or fettling. When the furnace was rebuilt, 10.2 tons of Siemensite bricks had to be renewed in the backwall, because the Siemensite had started to wear, beginning in the middle of the backwall near the roof skewback. The silica trickling down from the roof flowed over the Siemensite in the backwall, cutting out great grooves, in time necessitating a repair. When pulling down the damaged parts 5.5 tons of Siemensite granules were obtained that could be used in other places.

The thickness of the backwalls in the stationary 150-tons furnaces is very limited in order to obtain this big capacity. Their height from fore-plate level to roof skewback is 5 ft. For these backwalls the most varied refractory materials were tried, *e.g.*, magnesite, sintered magnesite, rammed in metal cases and walls rammed in dolomite. None of these methods gave satisfactory results; the backwalls had to be repaired several times during the lifetime of the furnace, and were more expensive to put up and maintain than the backwalls in Siemensite. It is important that Siemensite backwalls should be laid on a good magnesite base (Fig. 5).

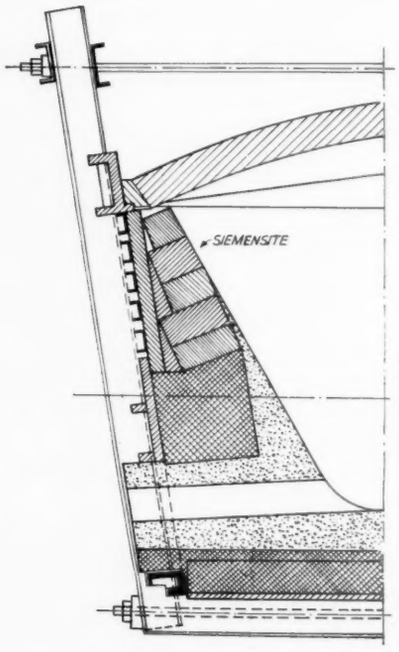


Fig. 5.

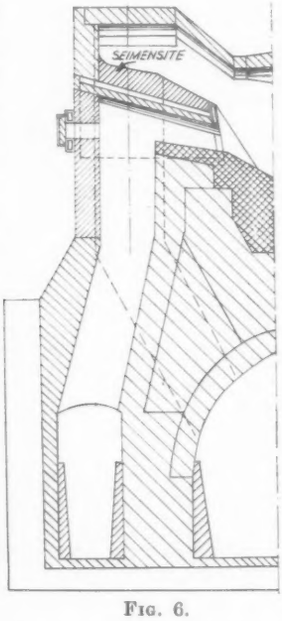


Fig. 6.

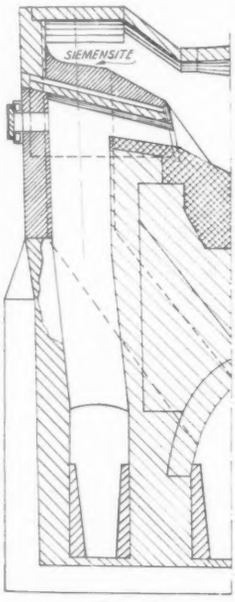


Fig. 7.

Fig. 8.—Showing Provision for Expansion of Joints.

Fig. 9.—Showing Construction of Wing Walls and Block Ends in Siemensite.

Trials at Gas-Port Stoppings.

A part of the open-hearth furnace which is subjected to very severe conditions is the gas-port stoppings, especially in cases where high gas velocities are used. In order to avoid the frequent and troublesome repairs the stoppings were built in Siemensite. The first gas-port stopping built of Siemensite in furnace No. 2 (Fig. 6) had to be removed after 110 heats (16,500 tons of steel) because the inside brickwork of the water-cooled gas port had to be renewed. When a Siemensite stopping was installed in the furnace No. 1 (Fig. 7) the silica brickwork underneath had melted away badly (Figs. 6 and 7). It was therefore found necessary in vertical uptakes to continue the Siemensite brickwork to a lower level. Further gas stoppings in furnace No. 3 attained a life of 155 heats (23,323 tons of steel).

When laying Siemensite the most careful attention must be paid to providing expansion joints of sufficient size (Fig. 8). It is not necessary to observe a regular bond in building. In most cases only a few shapes of brick will be required. The construction of wing walls and block ends in Siemensite can be seen from Fig. 9. As mortar for Siemensite ground chromite or Siemensite is used mixed with sufficient clay for binding purposes. The Siemensite granules remaining after pulling down furnace ports can be used again for walls with sufficient slope, *e.g.*, gas port arches, wing walls, etc. The old Siemensite scrap not suitable for this purpose yields an excellent material for fettling door jambs and other parts after it has been ground and mixed with a little clay.

In determining the production attained the results on furnaces Nos. 1 and 3 will be considered because only these furnaces have been operating during the last two years. By melting capacity is usually meant the production of a furnace during one hour of pure melting, but as this amount does not correspond at all with the true melting capacity of a furnace this will be calculated for the whole of the time from the beginning of the first charge until the laying off of the furnace for a rebuild. The melting capacity includes, therefore, all stoppages on Sundays and holidays, for hearth repairs, hearth re-making and for the time of warming up the furnace. Working on these lines the following results were obtained:—*Furnace No.* 1—The melting capacity was 8.93 tons of steel per hr. for a production of 70,173 tons. *Furnace No.* 2—The melting capacity was 8.9 tons of steel per hr. for a production of 73,208 tons.

(To be concluded.)

American Progress in the Use of Alloys in Cast Iron.

[American Exchange Paper.]

By F. B. Coyle.

(*Continued from page* 11.)

Heat-Treatment of Alloy Cast-Iron Dies.

The hardening treatment consists of the following steps:—(*a*) Heat to 857 deg. C., and hold 1 hr. for each in. of thickness; (*b*) quench in oil; and (*c*) reheat between 260 deg. C. and 538 deg. C. until hardness test shows 300 to 320 Brinell.

Heat-treated alloy cast-iron dies are also successfully used for drop-forging and hot-processing in a number of particular instances. They resist the action of heat and resist shock. They

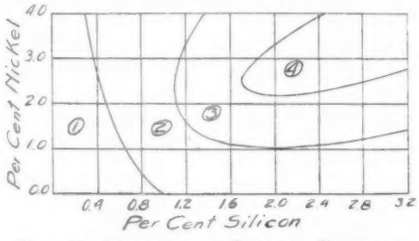


FIG. 10.—RANGES OF TENSILE STRENGTH OBTAINABLE WITH VARIOUS SILICON AND NICKEL CONTENTS IN LADLE-GRAPHITISED CAST IRON CONTAINING 2.7 PER CENT. TOTAL CARBON.

Area.	Tons per sq. in.
1	17.8 to 21.3
2	21.3 to 26.8
3	26.8 to 31.3
4	Over 31.3

compare well with steel dies for forming shovel blades and shanks, plough points, cultivator teeth and other parts of farm implements. They are also used successfully for drop-forging dies when only a limited number of pieces are required. Material costs can be reduced due to the low cost of alloy cast iron compared with expensive die-steel. Die-sinking costs are considerably reduced because impressions are cast nearly to shape or can be formed by squeezing a sample piece between two heated blocks.

The compositions of alloy cast-iron dies for forging or hot-processing in general use are: (A) T.C., 3.2 to 3.4 per cent.; Si, 1.25 to 1.5; Ni, 2.0 to 2.5, and Cr, 0.75 to 0.9 per cent., and (B), T.C., 3.0 to 3.2 per cent.; Si, 2.0 to 2.2; Ni, 0.6 to 0.8, and Mo, 0.6 to 0.8 per cent. The heat-treatment for drop-forging dies is the same as that used for pressing dies.

High-Strength Cast Iron.

It is generally considered, in America, that iron within the tensile-strength range of 17.7 tons/sq. in. to 22.3 tons/sq. in. is most promising for general application where high unit-strength in castings is essential. However, there is a definite field of application for iron castings with unit-strength above these limits. Production of irons of this last type is limited chiefly because they require special procedure and precise metallurgical supervision. Otherwise it would be foolish to attempt to produce these irons.

Alloy high-strength cast iron, as produced in America, can be embraced by three classifications, each corresponding to a method of manufacture, as follows:—

(1) Low total-carbon irons; (2) ladle-graphitised irons, and (3) heat-treated irons.

Low total-carbon irons are produced in the cupola by using charges consisting of 70 per cent. or more of steel scrap and a balance of silvery pig, cast-iron scrap and ferro-alloys. They are also produced in electric furnaces by synthesis from steel scrap or from steel scrap, iron scrap and ferro-alloys. Plain high-strength cast iron of this type usually has a tensile-strength range from 20 tons sq. in. to 29 tons /sq. in. (Nos. 1a, 1b, 1c in Table X). Alloy high-strength irons are usually included within the tensile-strength range of 22.3 tons/sq. in. to over 31.3 tons/sq. in., depending upon the composition (Nos. 1d, 1e, 1f, 1g and 1h in Table X).

High-strength cast irons produced by the ladle graphitisation process[6] with tensile strengths ranging from 22.3 tons sq. in. to more than 31.3 tons sq. in. is produced in thirty-eight foundries in America and marketed under various trade names, including "Ni-Tensyliron," "Maxtensile," "Fultonite," "Cochrain Alloy," and others. It is made by melting down a low-carbon (under 3.0 per cent. total carbon), low silicon-base composition, which if cast directly, would result in castings having a white fracture. Graphitising elements, such as silicon and nickel, are added to the melt, whilst it is being teemed from the furnace, or immediately before tapping from the furnace, in desired quantities. It is produced by the cupola, electric-furnace and air-furnace processes. In the cupola low total carbon is obtained by using charges consisting of 70 to 95 per cent. steel scrap and the balance, silvery pig, containing 8 to 16 per cent. silicon, cast-iron scrap and ferro-alloys. In the electric-furnace the charge consists of similar materials, except that lower percentages of steel scrap are used. In some instances the charge consists of steel scrap, ferro-silicon or silvery pig and petroleum coke. In the air furnace a normal malleable-iron melt is used as a base. Suitable base-metal compositions and ladle additions are given in Table XI. Methods 2, 3, 4 and 5 of Table XI are those most commonly used and produce most uniform results. The range of tensile strength obtained will depend upon the relative proportions of ultimate silicon and nickel content, as shown in Fig. 10. The presence of carbide-forming elements slightly retards the rate of graphitisation and affords better control. Physical characteristics of this type of iron are given in

TABLE VI.—*Typical Applications of High-Test Cast Iron.*

TC	Mn	P	S	Si	Ni	Cr	Mo	Transverse breaking load-Lbs.	Deflection	BHN	Tensile Strength psi	Tensile Strength Tons Sq.in.	Application
3.26	0.56			2.06			0.26	4,500	.139	207	42,900	19.15	Auto Cylinder blocks (1)
3.25	0.56			2.06			0.82	5,020	.147	217	45,705	20.40	" " " (1)
3.23	0.56			2.06		0.27	0.39	4,840	.121	228	49,985	22.30	" " " (1)
3.45	0.81	0.23	0.096	1.85			0.73			207	44,300	19.75	General jobbing castings (1)
3.09		0.20	0.10	2.22			0.35	6.000	.160	255	47,000	20.90	" " " (1)
3.10	0.65	0.20	0.10	1.40	1.75	0.50				220	42,000	18.75	Diesel Engine housing
2.85	0.80			1.75	1.50					240	44,000	19.65	Heavy duty machine tool beds
3.00	0.80			1.00	2.00					220	42,000	18.75	Heavy gears
3.00	0.60			1.00	1.25					220	42,000	18.75	Elevator sheaves
2.90	0.60			0.90	1.50					200	42,000	18.75	Heavy machine tool beds
3.10	0.60			1.50	2.00	0.60				200	42,000	18.75	Heavy cams
3.30	0.65			1.75	1.75	0.75				230	40,000	17.75	Melting pots
3.00	0.85			1.00	1.25	0.30				220	40,000	17.75	Hoist drums
3.30	0.75	0.10	0.12	1.00	1.50			5,000			40,000	17.75	Superheater body Diesel engine liners and heads
3.10	0.80	0.20	0.12	1.00	1.00					220	45,000	20.05	Connecting rod shoes and guides Air compressor blocks and heads

(1) Electric furnace cast iron - others cupola irons.

TABLE V.—*Representative Compositions of Alloy High-Test Cast Iron with Tensile Strength* 18 *to* 21.5 *tons per sq. in. in Use in America.*

Section	¼" to ½"	½" to ¾"	¾" to 1"	1" to 1¼"	1¼" to 1½"	1½" to 2"	1" to 2"	1" to 2"	2" to 4"	2" to 4"	2" to 4"
Brinell Hardness Machinability	180 Readily	220 Good	260 Economically	180 Readily	220 Good	260 Economically	180 Readily	220 Good	260 Economically	180 Readily	220 Good	260 Economically
Wear Resistance	Good	Very Good	Excellent	Good	Very Good	Excellent	Good	Very Good	Excellent	Good	Very Good	Excellent
Density	(4)	(5)	(5)	(4)	(5)	(5)	(4)	(5)	(5)	(4)	(5)	(5)
Total Carbon	3.20-3.40	3.10-3.30	3.00-3.20	3.10-3.30	2.90-3.10	2.80-3.00	3.00-3.20	2.90-3.10	2.80-3.00	2.90-3.10	2.80-3.00	2.70-2.90
Manganese	0.55-0.75	0.55-0.75	0.55-0.75	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95
Phosphorus (1)	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Sulphur (1)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.12	0.12
Silicon	1.60-1.80	1.40-1.60	1.20-1.40	1.20-1.40	1.10-1.30	1.00-1.20	1.00-1.20	1.00-1.20	0.90-1.10	0.90-1.10	0.80-1.00	0.70-0.90
Nickel	1.25	1.25	2.00	1.25	1.75	1.75	1.25	1.75	1.25	2.00	2.00	
Chromium	None	None	None	None	None	0.25-0.35	None	None	0.25-0.35	0.25-0.35	0.35-0.45	0.50-0.60

(1) Maximum (2) Minimum (3) Sound in uniform sections.
(4) Sound within section limits at top of column.
(5) Sound throughout widely varying sections.

[6] U.S. Patent 1,867,732, July 19, 1932; Canadian Patents 300,398, May 20, 1930, and 324,552, July 26, 1932; British Patents 290,267, May 13, 1927, and 352,510, January 5, 1929.

Table XII. Typical industrial applications, including castings weighing from one ounce to more than thirty tons, are as follow:—Diesel-engine cylinders; Gear casings; Crusher frames; High-pressure pump cylinders; High-pressure pump frames; Colliery winding drums; Piston

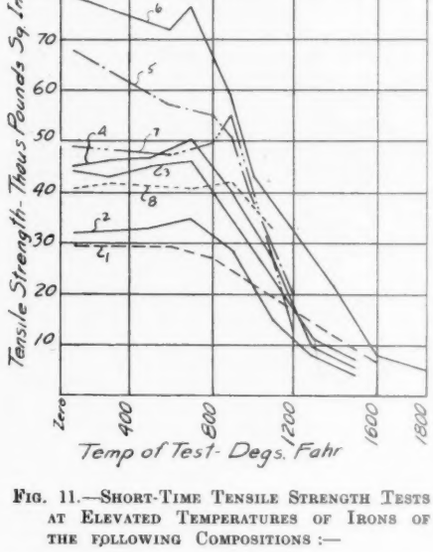


Fig. 11.—Short-Time Tensile Strength Tests at Elevated Temperatures of Irons of the following Compositions:—

Number ..	1	2	3	4	5	6	7	8
Total carbon..	2.95	3.40	3.20	2.95	2.78	2.60	2.40	2.61
Manganese ..	0.85	0.75	0.85	0.75	0.80	0.25	0.70	0.82
Silicon ..	1.64	1.50	1.15	2.45	1.79	0.90	1.57	1.20
Nickel ..	13.02	—	1.50	—	1.59	1.25	1.34	2.39
Copper ..	6.29	—	—	—	—	—	—	—
Chromium ..	3.55	—	—	—	—	0.40	—	—
Temp. of falling off in strength ..	600	700	700	700	800	800	900	900

rings; Heavy-duty gears; Heavy-duty pinions; Superheater bodies; Sheet-pressing dies; Heavy-duty cams; Drop-forging dies (for brass and bronze); Valve bodies; Sugar-mill frames; Turbine casings; Turbine rotors; Tractor bearings; Automatic machine-tool spindles; Hydraulic-press cylinders; Diesel-engine housings; Glass moulds; Wire-drawing machine frames; Worm wheels; Differential housings; Heat interchangers; and Auto-brake drums.

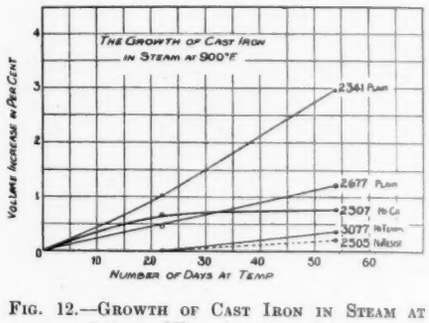


Fig. 12.—Growth of Cast Iron in Steam at 900 deg. Fah. (482 deg. C.).

Heat no.	Type.	Analysis. T.C.	Si.	Ni.	Cr.	Cu.
2341	Plain	3.48	2.02	—	—	—
2677	Plain	3.36	0.82	—	—	—
2307	Ni-Cr	1.39	0.96	0.96	0.33	—
3077	Ni-Tensyliron..	2.89	2.45	1.45	—	—
2505	Ni-Resist ..	3.04	1.64	13.63	3.23	6.48

Alloy high-strength cast iron can also be produced by two methods of heat-treatment:—(1) Annealing alloy white-iron; (2) quenching and tempering grey alloy high-strength iron.

The first method consists of casting a composition corresponding to 3d shown in Table X. Castings of this composition 3d (known as Jewell Alloy) are used in the following applications:—Locomotive grate bars; Stoker links; Optical-glass dies; Gas-burner parts; Sintering grates; Hanger beams; Gatlings; Grizzly bars; Brackets; Pneumatic cylinders; Compressor-valve seats;

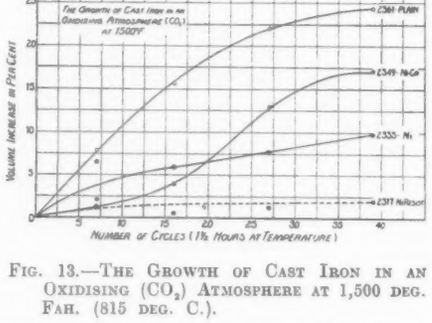


Fig. 13.—The Growth of Cast Iron in an Oxidising (CO_2) Atmosphere at 1,500 deg. Fah. (815 deg. C.).

Heat no.	Type.	Analysis. T.C.	Si.	Ni.	Cr.	Cu.
2361	Plain	3.26	2.02	—	—	—
2349	Ni-Cr	3.43	1.08	2.33	0.49	—
2511	Ni	3.08	0.14	4.01	—	—
2517	Ni-Resist ..	2.88	1.72	14.31	3.92	5.37

Superheater castings; and Lathe carriages and slides.

Corrosion-Resistant Cast Iron.

In 1929 a high-alloy-content cast iron was introduced to American industry for applications

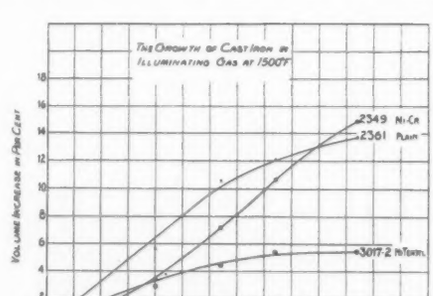


Fig. 14.—The Growth of Cast Iron in Illuminating Gas at 1,500 deg. Fah. (815 deg. C.).

Heat no.	Type.	Analysis. T.C.	Si.	Ni.	Cr.	Cu.
2361	Plain	3.26	2.02	—	—	—
2349	Ni-Cr ..	3.43	1.08	2.33	0.49	—
3017-2	High Strength	2.81	1.88	1.84	—	—
2327	Ni-Resist ..	2.60	0.48	13.17	1.48	6.50
2317	Ni-Resist ..	2.88	1.72	14.31	3.92	5.37

where an economically-priced corrosion-resistant material would prove desirable.[7] There are two general types of this alloy cast iron in common use:—(1) T.C., 2.75 to 3.10; Si, 1.25 to 2.00; Ni, 12.00 to 15.00; Cu, 5.00 to 7.00; and Cr, 1.50 to 6.00 per cent.; and (2) T.C., 2.75 to 3.10; Si, 1.25 to 2.00; Ni, 20.00 to 30.00; Cu, none; and Cr, 1.00 to 4.00 per cent. The following is the approximate production of this material

Table VII.—*Properties of Regular and High-Test Cast Iron Locomotive Cylinders.*

	Regular Cylinder Iron	Alloy High Test Iron
Steel scrap in charge	15%	60%
Total Carbon	3.15% to 3.40%	2.75% to 3.15%
Manganese	0.60% to 0.90%	0.60% to 1.00%
Phosphorous	under 0.35%	under 0.20%
Sulphur	" 0.10%	" 0.12%
Silicon	1.30% to 1.50%	0.90% to 1.10%
Nickel	none	1.00% to 1.25%
Tensile strength (Arb bar)	25,000 to 32,000 psi. (11.6 to 14.28 tons)	37,500 to 46,100 psi. (16.75 to 20.6 tons)
Tensile center of 4" round	14,000 to 18,000 psi. (6.5 to 8.4 tons)	29,900 to 32,800 psi. (13.35 to 14.66 tons)
Transverse break in load	2,200 to 3,300 lbs.	4,640 to 5,540 lbs.
Deflection	0.17 to 0.18	0.15 to 0.19"
Brinell Hardness (Arb bar)	160 to 170	220 to 240
(center of 4" round)	146 to 149	175 to 207

(known in America as "Ni-Resist") since its introduction in 1929:—

Year.	Pounds "Ni-resist" Produced.
1929	305,000
1930	560,000
1931	750,000
1932	1,660,000

The essential difference between this material and grey iron is that the metallic structure is austenitic. The physical properties are:—*Tensile strength*, 8.94 to 15.62 tons per sq. in.; *transverse breaking load in lbs.* (1¼ in. by 12 in.), 2,500 to 4,000; *deflection in ins.*, 0.20 to 0.30; *Brinell hardness number*, 120 to 170. The lower values correspond to 1.5 per cent. chromium content and the higher values correspond to 3.5 per cent. chromium content. The copper-bearing composition is considered standard, and its resistance to corrosion in contact with various media compared with other metals is given in Tables XIII to XV.

Table VIII.—*Compositions of Plain and Alloy Heat-Treated Cast Irons.*

Number	Total Carbon	Manganese	Silicon	Nickel	Chromium	Quenching Temp °F.	Quenching Temp. °C.
1	3.37	0.58	1.49	-	-	1550	847
2	2.78	0.74	2.58	-	-	1575	857
3	2.54	0.78	2.51	1.05	-	1575	857
4	3.15	0.54	1.73	0.97	-	1525	830
5	3.13	0.79	1.02	3.89	-	1450	788
6	3.36	0.56	1.50	1.22	0.58	1550	847
7	3.44	0.63	1.55	2.22	0.96	1525	830
8	3.15	0.66	1.16	3.16	0.66	1475	802
9	3.37	0.52	1.47	3.46	1.56	1500	815

Phos. under .20
Sulphur under .12
All specimens quenched in oil.

The copper-free composition is used in caustic evaporating equipment and food-canning machinery. In operation, caustic evaporators are fed with a caustic solution previously concentrated (to 100 deg. T.W.). The evaporator is supplied with steam at 75 lbs. per sq. in. pressure, and evaporation accomplished under a vacuum of 26 in. of mercury. The final product of the evaporator is caustic soda concentrated to 130 deg. T.W. The comparative resistance of copper-

Table IX.—*Composition of Alloy Cast-Iron Dies.*

Type.	1.	2.			3.	4.
T.C.	3.00—3.25	2.75—3.25	2.75—3.25	3.1—3.4	2.8 —3.0	3.0— .3
Si	1.00—1.50	0.06—1.5	1.75—2.0	1.5—2.35	1.25—1.5	1.7— .8
Ni	1.75—2.00	2.0 —3.5	2.5 —3.0	—	1.5 —2.0	5.5— .0
Cr	0.5 —0.75	0.5 —1.0	1.25—1.5	—	0.25—0.5	0.5— .6
Mo	—	—	—	1.0—1.6	—	—
V	—	—	0.1 —0.15	—	—	—

[7] U.S. Patent 1,867,018.

free "Ni-Resist" and other types of cast iron in caustic evaporation is given in Table XVI. This material is manufactured by the cupola, electric-furnace, air-furnace and crucible-melting processes.

There are two general procedures followed in all of the above melting processes. These differ only in the nature of the furnace charges, which

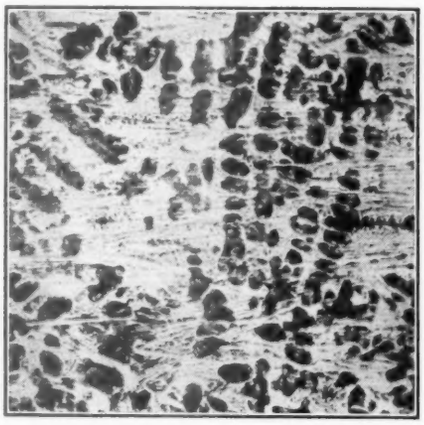


FIG. 15A.—STRUCTURE OF PLAIN CHILLED IRON (100 MAG.).

are:—(*a*) Monel-metal scrap, 20; 70 per cent. ferro-chromium, 2 to 5; and cast-iron scrap, 75 to 78 per cent.; and (*b*) nickel-copper-chromium pig, 25; and cast-iron scrap, 75 per cent. The composition of the nickel-copper-chromium pig metal used in method (*b*) is as follows:—Ni, 56.0 per cent. (min.); Cu, 23.0 per cent. (min.); Cr, 7.5 per cent. (min.); C, 1.00 per cent. (min.); Si, 0.25 per cent. (min.); and balance Fe impurities. The melting point is 1,260 deg. C.

Another alloy cast iron known as Pyrocast, Duralloy, etc., has been manufactured to a limited extent for corrosion-resistance applications. It contains 2.5 to 3.5 per cent. carbon; 1.0 to 2.5 per cent. silicon, and 16.0 to 25.0 per cent. chromium. It has been difficult to collect any further information regarding this material other than that it resists the action of nitric, sulphurous, phosphoric, acetic and lactic acids,

FIG. 15B.—STRUCTURE OF PLAIN CHILLED IRON, SHOWING PEARLITIC GROUND MASS (500 MAG.).

as well as sodium hydroxide, ammonium and potassium nitrates, ferric and zinc chlorides, sodium sulphide and ammonium sulphate.

Heat-Resistant Cast Iron.

The chief drawbacks to the application of grey iron at elevated temperatures have been:—(1) Reduction of strength and creep; (2) growth and warpage, and (3) scaling. The application of cast iron has been found to depend also upon the range of temperature involved. There are two general ranges of temperature which, while requiring resistance to the fundamental difficulties represented above, require essential inherent differences in the materials used because of the difference in degree of resistance required within the two temperature ranges. These temperature

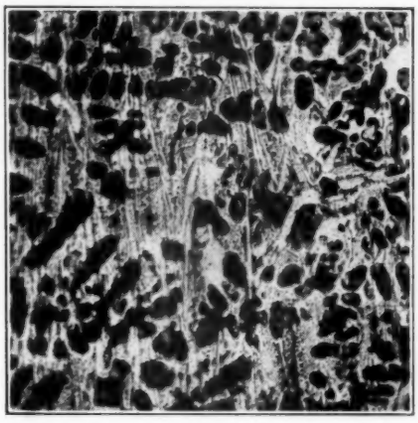


FIG. 15C.—STRUCTURE OF MEDIUM ALLOY CHILLED IRON, CONTAINING 2.5 PER CENT. NI AND 0.80 PER CENT. CR (100 MAG.).

ranges are:—(1) The temperature range up to 593 deg. C. and (2) the temperature range above 593 deg. C.

Fig. 11[8] shows short-time tensile tests of a number of types of cast iron. In general strength is maintained uniformly up to 371 to 482 deg. C. before falling off. The lower carbon and silicon irons show the highest temperature before falling off in strength. In these irons, nickel is of distinct advantage because it permits the use of low carbon and silicon without danger of chilled sections. Above 371 to 482 deg. C. the tensile strengths of all types of iron fall off uniformly to approximately the same value—3.57 to 4.67 tons/sq. in.—at 704 deg. C., except the partially-malleabilised nickel-chromium iron (No. 6), which has a tensile strength of approximately 8.9 tons per sq. in. at 704 deg. C. The high-

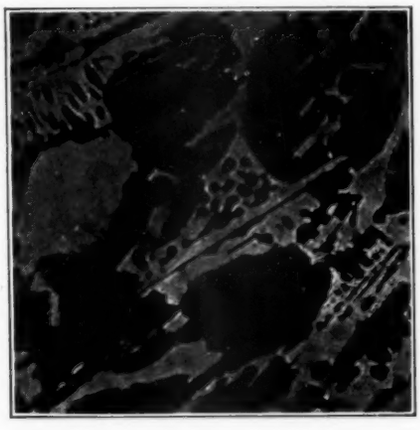


FIG. 15D.—STRUCTURE OF MEDIUM ALLOY CHILLED IRON, CONTAINING 2.5 PER CENT. NI AND 0.80 PER CENT. CR, SHOWING TROOSTITIC GROUND MASS (500 MAG.).

strength irons have approximately double the strength of common grey iron at 538 deg. C.

Very little investigation has been made of the creep characteristics of cast iron, but what few tests have been made indicate that low-carbon

[8] Symposium on "Effect of Temperature on Metals," A.S.T.M., 1931, p. 460, Jewell Steel and Malleable Co. and The International Nickel Co. Research Laboratory.

and alloy cast irons show marked superiority when subjected to a working stress of 45 tons per sq. in. between 371 and 454 deg. C.[9]

In Fig. 12 is given the results of tests to show the growth characteristics of various compositions of grey iron in steam at 482 deg. C. Nickel-chromium, high-strength or austenitic irons show low growth and retain their strength

FIG. 15E.—STRUCTURE OF HIGH-ALLOY CHILLED IRON, CONTAINING 4.5 PER CENT. NI AND 1.5 PER CENT. CR (100 MAG.).

under these conditions. In the temperature range above 593 deg. C., requirements to resist the effects of heat are more severe than in the lower-temperature range. The growth of various compositions of grey iron in oxidising and reducing atmospheres at 816 deg. C. is shown in Figs. 13 and 14. The advantage of austenitic cast iron under these conditions is apparent.

In Table XVII is shown the relative resistance of several grey-iron compositions to scaling in an oxidising atmosphere at 816 deg. C. Here, again, it is clear from these data that in the temperature range above 593 deg. C. the austenitic type of irons is not only most suitable but is economical as well. In Table XVIII are given some representative compositions in which alloy cast irons have shown their suitability for service at elevated temperatures.

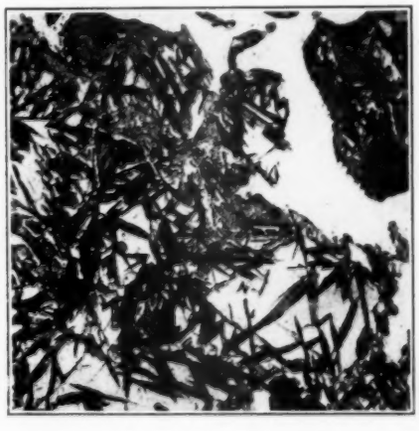


FIG. 15F.—STRUCTURE OF HIGH-ALLOY CHILLED IRON, CONTAINING 4.5 PER CENT. NI AND 1.5 PER CENT. CR, SHOWING MARTENSITIC GROUND MASS (1,000 MAG.).

The two following types of chromium cast iron are also used extensively for heat-resistant applications such as annealing boxes, grate bars, stoker links, tuyeres and manifolds:—Type A: T.C., 2.5 to 3.5 per cent.; Si, 1.0 to 2.5, and

[9] Symposium on "Effect of Heat on Metals," A.S.T.M., 1931, p. 461; "Alloys of Iron and Molybdenum": Gregg. McGraw Hill Co., pp. 189 and 191.

XUM

Cr, 16.0 to 25.0 per cent., which gives a transverse load of 4,000 to 6,000 lbs. with a deflection of 0.10 to 0.11 in. and a Brinell hardness number of 375 to 444, and Type B: T.C., 1.8 to 2.5 per cent.; Si, 1.0 to 2.5, and Cr, 22.0 to 30.0 per cent., which has a Brinell hardness number of 250 to 300. After heating for 148 hrs. in an oxidising atmosphere at 815 deg. C., Type A showed an increase in weight of 0.03 per cent. due to a closely-adhering protective film, whilst a plain iron showed a loss of 8.0 per cent. due to scale. After 48 hrs. at 1,000 deg. C. in an oxidising atmosphere Type B showed a gain of 0.02 per cent. to 0.10 per cent. in weight, whilst a plain iron lost 24.20 per cent. in weight due to scale.

TABLE X.—*Typical Applications of High-Strength Cast Irons.*

No.	TC	Mn	P	S	Si	Ni	Cr	Mo	Transverse Breaking Point Pounds	Deflection	BHN	Tensile Strength p.s.i. tons sq. in.		Application	Notes
1a	2.97	0.88	0.12	0.142	2.38	(4)	(4)	(4)	4,100	.135	241	47,650	21.25	General Machinery castings	
1b	2.80	0.79	0.07	0.152	2.71	(4)	(4)	(4)	3,740	.125	255	50,700	22.65	" " "	
1c	2.95	1.57	0.09	0.148	2.84	(4)	(4)	(4)	4,040	.125	255	56,700	25.35	" " "	
1d	2.66	0.50	0.224	0.075	2.54	(4)	(4)	0.35	5,370	.130	(5)	50,100	22.40	Automobile Cyl.Blocks	(2)
1e	2.85	0.85	0.10	0.10	2.55	1.63	0.40	(4)	5,180	(5)	240	54,900	24.45	Machine Tool Castings	(1)
1f	2.97	1.07	0.10	0.162	2.92	(4)	(4)	0.82	5,120	.160	302	89,800	26.85	" " "	
1g	2.78	(5)	(5)	(5)	1.91	2.46	(4)	0.55	4,700	.126	286	60,000	26.80	Automobile cylinder blocks and pistons	(2)
1h	3.25	1.08	(5)	(5)	2.39	0.75	(4)	0.70	(5)	(5)	241	66,500	29.70	" " " "	
2a	2.99	0.73	(5)	(5)	1.60	1.07	0.78	(4)	6,160	.152	321	64,500	28.80	General Machinery Catgs.	
2b	2.82	1.03	(5)	(5)	2.20	2.74	0.65	(4)	4,670	.152	302	64,910	28.95	" " "	
2c	2.75	0.80	0.20	0.12	1.75	2.00	(4)	(4)	(5)	(5)	240	62,800	28.02	Diesel engine housing	
2d	2.76	0.63	0.12	0.07	1.91	0.66	(4)	(4)	6,240	.250	269	66,160	29.50	Miscellaneous light castings	
2e	2.73	0.65	0.12	0.07	2.59	1.11	(4)	(4)	5,540	.250	269	70,400	31.40	" " "	
3a	2.80	(5)	(5)	(5)	2.00	0.75	0.20	0.75	(5)	(5)	360	60,000	26.80	Automobile Cam Shaft	(2)(3)
3b	2.75	0.85	0.031	0.097	2.41	1.80	0.42	(4)	(5)	(5)	321	81,050	36.20	Machine Tool Castings	(6)
3c	2.90	0.80	0.07	0.09	1.35	1.75	0.35	(4)	(5)	(5)	320	88,640	39.40	Sheet Metal Drawing Dies	(6)
3d	2.60	0.25	0.04	0.05	0.90	1.25	0.40	(4)	(5)	(5)	230	87,550	39.10	Grate bars, general jobbing castings	(7)(8)(9)

Notes (1) Difficult to machine.
(2) Melted in electric furnace. All others except 3d melted in cupola
(3) Annealed at 1600°F. machined, air cooled from 1600°F. to 1650°F. BHN 400.
(4) None added.
(5) Not determined.
(6) Oil quenched from 1575°F. drawn at 950°F.
(7) Melted in air furnace.
(8) Annealed 12 hrs. at 1650°F.
(9) Yield point 58,630 p.s.i. elongation 8.3% in 2"

Alloy White and Chilled Iron.

In 1929 an alloy cast iron for white iron or chilled iron applications was introduced to American industry under the name of "Ni-Hard" cast iron.[10] There are three general types of this iron produced:—

Type.	T.C.	Si.	Mn.	S.	P.	Ni.	Cr.	Appl.
A	2.7—3.6	See Table XIX	0.35—0.50	0.12 max.	0.20 max.	4.25—4.75	1.4—1.6	Chilled surface.
B	2.7—3.6	See Table XX	0.35—0.50	0.12 max.	0.30 max.	4.25—4.75	1.4—1.6	White fracture sand castings.
C	3.4—3.6	0.8—1.0	1.25—1.50	0.12 max.	0.20 max.	4.00—4.50	1.4—1.6	Chilled rolls.

Some producers add 0.25 to 0.35 per cent. molybdenum to the above compositions in order to increase toughness slightly, and some add 0.35 per cent. vanadium to increase the hardness of the chill and prevent any possibility of columnar structure in the chill. This material is made by the cupola, electric- and air-furnace processes. Its production since 1929 has been as follows:—

Year.	Tons "Ni-hard" produced.
1929	144
1930	438
1931	357
1932	3,165

The effect of additions of nickel and chromium upon the structure of chilled-surface or white-fracture cast iron is twofold:—(*a*) Addition of nickel and chromium progressively refines the carbide network (white) as shown in Figs. 15a, 15c and 15e, and (*b*) nickel and chromium alter the ground-mass progressively from pearlite through sorbite and troosite to martensite (the dark-toned constituents) as shown in Figs. 15b, 15d and 15f. It is the combination of cementite (white) and martensite (dark) as shown in Fig. 15f, which contributes to the higher hardness, strength, toughness and resistance to wear which this material possesses in comparison with plain white fracture or chilled-surface cast iron.

Depth of Chill.

Silicon and mass have a relatively mild effect upon the depth of chill of "Ni-Hard." However, the effect of total carbon is decidedly pronounced, as shown in Fig. 16. An increase of 0.5 per cent. silicon in an iron containing 3.25 to 3.5 per cent. carbon. 4.0 per cent. nickel and 1.0 to 1.5 per cent. chromium and 0.65 per cent. silicon, will reduce the depth of white iron in chill blocks about 0.25 in. Starting with 3.0 per cent. total carbon an increase of only 0.20 per cent. in total carbon to the foregoing composition will cause a reduction of about 1.25 in. in depth of chill. It is essential, then, in order closely to regulate the depth of chill, that the total carbon be controlled within narrow limits. In Fig. 16 is also shown the variation of hardness of the chilled surface of "Ni-Hard" with total-carbon content.

The Brinell hardness of the chilled face increases with the total carbon, even though the depth of chill decreases. This is due to the increased amount of carbide present. In air-furnace iron, the manganese is usually low—just enough to take care of sulphur present. In cupola practice, the manganese is generally higher in order to prevent oxidation. Some producers maintain the manganese between 0.35 and 0.45 per cent. The addition of sulphur, as pyrites, in the ladle will unbalance the manganese-sulphur proportion and increase depth of chill. The addition of each 0.01 per cent. sulphur (between 0.10 and 0.20 per cent. sulphur) in this manner will increase the depth of chill approximately 0.01 in. The depth of chill in high-carbon irons can also be increased approximately 1 in. by increasing the chromium content to 2.0 or 2.25 per cent., maintaining the nickel at 4.5 per cent.

Nickel-chromium white-fracture cast iron possesses an extra hard-wear-resistant surface, not only when cast against chills, but also when cast with a white fracture in conventional sand moulds. In this case it is necessary in order to obtain a white fracture that the silicon be lower than when cast against a chill. Whilst the Brinell hardness of this iron, when cast in sand, is slightly lower than when chilled, it is considerably higher than plain white or chilled iron. The Brinell hardness will range from about 475, with total carbon about 2.7 per cent., to 625 with total carbon about 3.50 per cent.

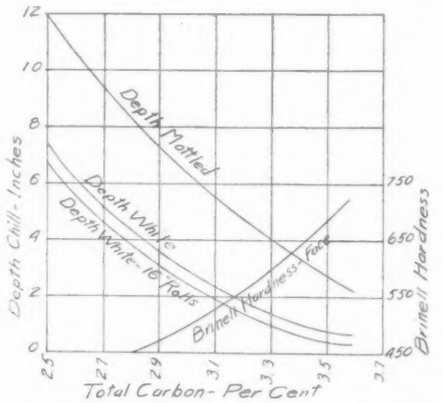


FIG. 16.—EFFECT OF TOTAL CARBON ON DEPTH OF CHILL AND BRINELL HARDNESS OF THE FACE OF 2-IN. BY 4-IN. BY 6-IN. AND 2-IN. BY 4-IN. BY 12-IN. CHILL BLOCKS CHILLED ON THE 2-IN. BY 4-IN. FACE OF IRON CONTAINING 0.6 PER CENT. TO 0.7 PER CENT. SILICON, 4.0 PER CENT. NICKEL AND 1.0 PER CENT. TO 1.5 PER CENT. CHROMIUM.

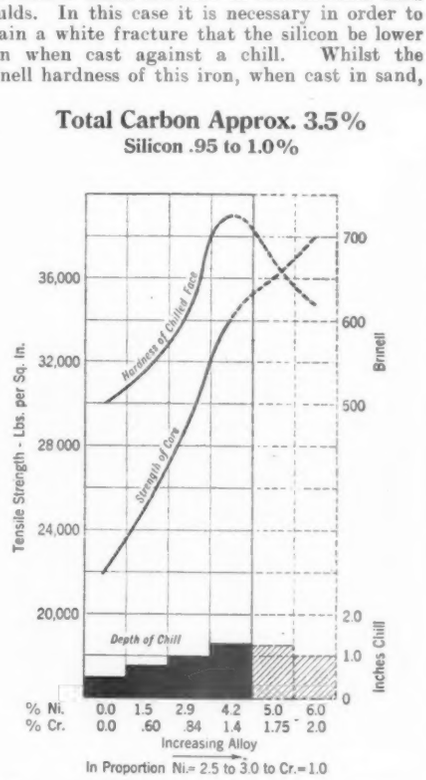


FIG. 17.—EFFECT OF INCREASING ALLOY CONTENT ON THE STRENGTH OF CORE, HARDNESS OF CHILLED FACE AND DEPTH OF CHILL OF CHILLED IRON CONTAINING 3.5 PER CENT. TOTAL CARBON.

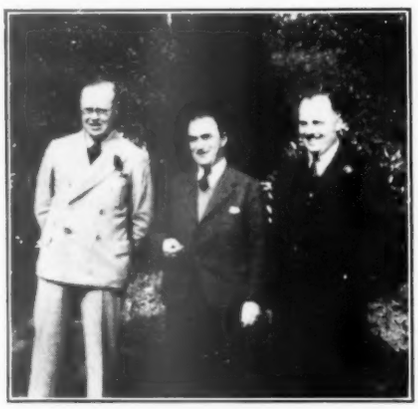
(*To be continued.*)

10 British Patent 279,414.

Institute of British Foundrymen.

LANCASHIRE BRANCH ANNUAL PICNIC TO GRINDLEFORD BRIDGE.

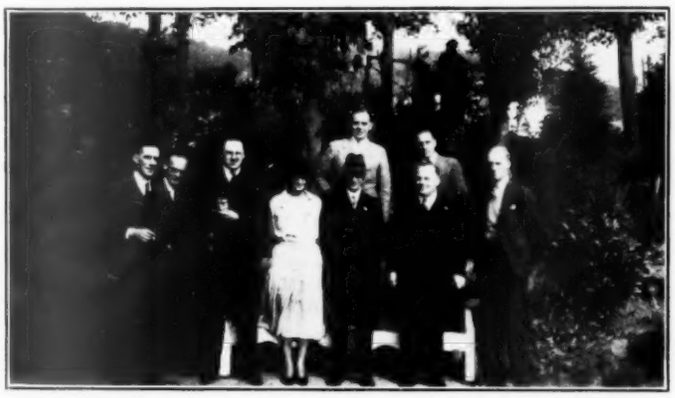
A very successful picnic, organised by the Lancashire Branch, took the form of a motor-coach outing on Saturday, July 1, 1933. Coaches from Burnley and Manchester carried a party of 60 members and their ladies by a picturesque route through Derbyshire to the Maynard Arms



AT THE LANCASHIRE ANNUAL PICNIC. (Mr. Roy Stubbs, Mr. Arthur Phillips and Mr. J. E. Hurst.)

Hotel, Grindleford Bridge. There they were met by 10 members of the Sheffield Branch, and the prowess of the party was exhibited at skittles, clock golf, a novelty target contest and at bowls.

MR. ARTHUR PHILLIPS, Branch-President, in welcoming the visitors, expressed the hope that the friendly rivalry of the day's contests would be followed by close co-operation between the Sheffield and Lancashire Branches in an endeavour to make the 1934 Conference of the Institute, in Manchester, and the 1935 Conference, in Sheffield, outstanding successes. MR. J. E. HURST (Sheffield), Junior Vice-President of the Institute, thanked the Lancashire Branch for



SHEFFIELD MEMBERS WHO JOINED THE LANCASHIRE BRANCH AT THEIR ANNUAL PICNIC.

their kind invitation to the Sheffield members, and cordially welcomed the suggestion of Mr. Phillips.

Dr. Skerl (Sheffield), Mr. and Mrs. T. R. Walker (Sheffield), Mr. T. Makemson (General Secretary) and Mr. and Mrs. J. W. Gardom (Dunstable) were amongst the visitors. Mr. and Mrs. Gardom had left Dunstable at 2.30 a.m. in order to be present. The prize winners included Mrs. W. N. Cook (Stockport), Mrs. Roy Stubbs (Cheadle), Mrs. Gardom (Dunstable), Miss Wilson (Rochdale), Mr. Gardom, Mr. Ellis Flower (Openshaw), Mr. J. Richardson (Accrington) and Mr. F. Harris (Padiham).

The Ladies' Committee for the 1934 Conference was also formerly inaugurated. Mrs. Roy Stubbs is to preside over this Committee and Mrs. J. E. Cooke is to act as its hon. secretary; several other ladies have indicated their willingness to help. The return journey by moonlight over the Pass by Mam Tor, the shivering mountain, provided a romantic and enjoyable conclusion to the day's experiences. The parties reached home in the early hours of Sunday.

Aluminium Blast-Furnace Tuyeres.

By TOSHIHIKO HIRAKAWA.*

During the past few years continuous experiments have been carried out on the methods of blast-furnace operation at Yawata, Japan, and as a result the operation has improved and output increased very considerably. Among other things, variation in the inner profile of the furnace and of the method of charging were made, and as a result No. 4 blast furnace, which has a nominal daily output of 250 tons, in 1928 provided an average daily output throughout the year of 365 tons. In 1929 the output was further increased, partly due to favourable conditions occurring in the winter of that year, and the average daily output amounted to 400 tons. At the same time, the steadiness of the furnace operation was improved. One detail, however, tuyere failures, remained as a problem for research. Such failures were frequent, especially with old blast furnaces, and were thought to be unavoidable, especially when using soft coke as at Yawata.

It is the experience of the author that the older the furnace and the quicker the rate of working, the greater will be the number of tuyere failures, and more especially is this the case when using soft coke. The number of failures at Yawata, with six furnaces in operation exceeded 1,000 annually. In 1927 the number mounted to the very high level of 1,760. At the Anshan Works in South Manchuria, where there are two blast furnaces only, the total number of tuyere failures was 710 in 1927 and 276 for the first ten months in 1928.

In most countries tuyeres are of copper, and failures of such tuyeres in normal "slow work" often occurs at the head of the tuyere through the wall becoming pitted and cracked by corrosion. Cooling water leaks from these pits and cracks and causes furnace trouble. At Yawata, however, there have been no instances of failure in this manner, and damage always occurs at a localised spot at the head, where a small conical hole appears as though bored by an insect. The dimensions of the hole vary with the thickness of the wall, the material employed and the rate of flow of the cooling water. After ten years' experience the author has found that the damage is always associated with poor operating conditions in the furnace. Where the charges are in powdered form, slags become low in fluidity, and there is a lowering of temperature at the tuyere zone. In other words, the failures occur where partial "roh gang" occurs in which molten iron is trapped at the tuyere zone and eventually makes contact with the head of the tuyere, superheating the point of contact. Slag itself cannot cause failure of the tuyere, however long it may be in contact, because it solidifies instantaneously and acts as an insulating coating. Thus, if in normal working slag makes contact with the tuyere head, no damage results, even though molten iron comes in contact afterwards. If, however, molten iron makes contact in the first place, it does not freeze in the same way, owing to its greater thermal conductivity, and the tuyere becomes overheated at the point of contact. As a result, the temperature of the cooling water rises, there is an evolution of air bubbles and, finally, steam bubbles are formed. The superheating at the contact point proceeds to the melting point of the tuyere material.

* Chief Engineer, Imperial Steel Works, Yawata, Japan.

Origin of the Aluminium Tuyere.

In 1920 the Yawata works were greatly enlarged, and as the fresh-water supply then became insufficient, the cooling water was changed to sea water. To avoid corrosion difficulties, all iron piping in the cooling system was replaced by lead piping; these pipes were found to be perfectly satisfactory, even in a white heat, provided that the cooling water constantly circulated. In view of this, the author considered that possibly aluminium might be used for the tuyeres, in spite of the fact that it has a lower melting point than copper. His view was that superheating is largely a function of the smoothness of the inner surface of the tuyere, because with a smooth inner surface the bubbles evolved are more easily carried away by the cooling water. Such smooth surfaces are obtainable by forging or pressing the tuyeres, but he hesitated to adopt this process of manufacture because of the very high cost. For this reason he commenced an investigation into the possibility of making suitable aluminium tuyeres by casting.

In June, 1923, an aluminium tuyere was installed in a blast furnace, and the author believes that this was the first time that aluminium has ever been used as a tuyere. The result of this experimental installation was fairly satisfactory, and in August, 1923, it was decided to adopt aluminium as the normal tuyere material. At that time No. 4 blast furnace was in its worst condition, and No. 10 tuyere was replaced by aluminium, this being followed later by replacement of copper tuyeres by aluminium at Nos. 9, 2, 5, 6 and 4. The aluminium tuyeres operated very satisfactorily, showing no sign of damage until October of that year, although very frequent failures of copper tuyeres had been experienced. In May, 1926, after various investigations, a test between copper and aluminium tuyeres, operating in parallel, was carried out on No. 2 blast furnace. Copper and aluminium tuyeres were installed alternately, and parallel running was continued about 40 days until June 30. The total number of failures of aluminium tuyeres was nine during this period, but for copper the number of failures amounted to 29.

In view of the excellent results from this and other tests, all the tuyeres at Yawata since 1927 have been made of aluminium.

The foregoing notes were extracted from Intelligence Memorandum issued by the British Aluminium Company, Limited.

Institute of British Foundrymen.

A WEST YORKSHIRE VISIT.

A special summer meeting of the West Yorkshire Branch of the Institute of British Foundrymen took place on Saturday, July 1, when a party of over 40 members assembled for a tour of the large engineering works of Messrs. Fairbairn, Lawson, Combe, Barbour, Limited, Wellington Road, Leeds. In the unavoidable absence of Mr. J. K. Anderson (managing director), who had been called away to Scotland, and Mr. N. Wailes Fairbairn, a director, who had intended to be present but was prevented unexpectedly, the party was welcomed by Mr. G. Willans (cashier) and Mr. George Auchterlonie (works manager), who conveyed to the visitors the greetings and good wishes of the directors and a cordial invitation to take full advantage of the opportunity for inspection of the works and plant and to ask any questions.

Mr. Willans and Mr. Auchterlonie, together with Mr. G. Beckett (assistant manager), Mr. A. E. Clapham (technician), Mr. J. Boocock (assistant cashier), Mr. F. Culley (foundry foreman), Mr. W. Horbury and Mr. B. Ellam (erecting foremen) and Mr. G. Parker (electrician) acted as guides during the tour.

The most outstanding impression gained by the visitors was of the vastness of the works, particularly when it is remembered that the company have a branch works at Belfast and are associated also with Messrs. Urquhart Lindsay & Robertson Orchar, Limited, of Dundee. The large foundry, naturally, attracted most attention, but the extensive machine shops, pattern shops and, finally, the erecting shop kept the party deeply interested throughout well over two hours. Certain of the finished plant in the erecting shop, connected up to a portable electric drive, was set in operation so that the visitors could see for themselves the actual working of the assembled parts as previously seen in the making.

History of the Firm.

The firm, it was explained, began making textile machinery in Leeds as long ago as 1812 at the Hope Foundry branch. The Wellington foundry, the subject of the visit, was established in 1828. The firm specialises in the manufacture of machinery for the treatment of flax, hemp, jute, sisal and analagous fibres for various grades of sacking, mattings, ropes, twines, etc. The machines made in Leeds comprise cards, drawing frames and roving frames for the preparation of the fibres, spinning frames, twisting frames and various types of rope-making machinery. The Belfast branch, it was explained, makes similar machines, but of a finer nature, and specialises also in certain machines made under a number of interesting patents of the company for the treatment of flax. The Dundee company with whom they are associated is engaged chiefly on the manufacture of winding, weaving and finishing machinery for the yarns produced on machinery made at the Leeds and Belfast works.

In 1930 a reorganisation scheme was put into operation, under which the plant from the Hope Foundry was transferred to an extended site at the Wellington Foundry, the new and thoroughly modern building for which was seen by the visitors. This is the largest engineering undertaking in the world engaged in this particular line of production.

The visitors saw a drawing frame, a roving frame and a spinning frame in operation on the preparation of jute yarn—machines which represent the very latest development of preparing and spinning machinery for jute, and which, it was naturally noted, involved the use of a large proportion of cast-iron parts as well as of steel. Detailing a little of the history of this great undertaking, the guides mentioned that the specialisation on machinery for flax and kindred fibres was a perpetuation of the original appeal of Yorkshire flax growers, in 1812, to Samuel Lawson, a Scottish engineer familiar with the kindred industry in North Britain, to devise machinery for spinning and twisting the native flax, a work hitherto undertaken chiefly by the housewife. Lawson, of an inventive turn of mind, accepted the proposition and set up a small works in Leeds for making his experimental plant. The first machines, crude by comparison with modern equipment, were sufficiently satisfactory to build up a substantial business, and in 1828 a further works of a similar kind was established, also in Leeds, by Sir Peter Fairbairn, another Scotsman. Both works prospered, and in 1830 the machinery adopted by Yorkshire flax workers extended to Scotland, particularly to Dundee. Irish workers followed suit, and in 1845 James Combe, another Scottish engineer, set up works at Belfast. The decline of the flax industry in about 1860 led to the plant in the engineering works being largely turned over to machinery for jute imported from India, there being a good deal of similarity in treatment. As far back as 1833 Samuel Lawson was granted a patent for certain improvements in machinery for preparing and drawing hemp, flax, wool and other fibres, which patent, it was explained by the guides, is the basis on which all such machinery is manufactured to-day for such fibres. It was in 1856 that the advent of the power loom caused the establishment of works at Dundee, by Provost Robertson and Provost Orchar, and a few years later Joseph Lindsay set up works of a similar character, also in Dundee. The works of all the separate firms steadily grew with the extension of the world demand for their machinery, and in 1900 the three firms in England and Ireland amalgamated as Fairbairn, Lawson, Combe, Barbour, Limited; and as the trend of events led to a closer working with the Dundee firms, specialising in weaving plant for the material produced on Leeds and Belfast machinery, the outcome was that in 1921 a direct link was established between all five firms, and to-day there is probably no flax, jute or similar fibre-working undertaking in the world without its complement of machinery from one or both of the Leeds-Belfast and Dundee associated firms.

Vote of Thanks.

At the conclusion of the tour of the Leeds works the visitors were entertained to tea in the canteen, Mr. R. D. Welburn, as President of the branch, presiding.

MR. H. ROBERTS (Leeds), proposing a hearty vote of thanks to the firm, said he had peculiar pleasure in doing so because he was himself for a good many years associated with that undertaking, and he regarded it, indeed, as the concern which gave him his first step upward in the engineering and foundry industry. In coming there that day he felt somewhat like "one of the family." One of the characteristics of the company had always been a willingness to co-operate for the good of any section of the engineering industry in which its own efforts might be of help, and the reception the visitors had had that day was quite in accordance with the spirit and tradition of the firm.

MR. S. W. WISE, Hon. Secretary of the West Riding branch of the Institute, seconding the expression of thanks, said the visitors particularly appreciated the frank and ready manner in which questions had been answered by the guides. It was essential that if foundrymen were to give the best service to the engineering trade within their power, they should understand something of the engineer's viewpoint on foundry products. On that occasion they had gained valuable insight into many phases of that viewpoint. They had seen foundry products put to many uses with which perhaps most people in the West Riding—essentially a wool-textile area—were not very familiar. The spirit of co-operation of this kind, one was glad to note, was steadily growing in the engineering industry, and it was all to the good. The Institution of British Foundrymen had as its primary object the raising of the status of all grades of foundry people, from the owner to the moulder and the apprentice, and by raising that status it was expected to raise also the efficiency of work and quality of product. They were grateful to a great firm of engineers which afforded facilities for helping in that direction.

MR. G. WILLANS, in a brief reply, said the directors were glad of the opportunity of affording facilities for the visit and only sorry they had not been able to be present to give the party a personal welcome. So far as concerned they of the staff who had remained behind to act as guides, it had been a pleasure to meet the visitors.

MR. A. S. WORCESTER, Immediate Past-President of the branch, proposing a vote of thanks to Mr. Willans and his colleagues for their help as guides, said visits of that kind enabled foundrymen to gain in knowledge in a manner which could not but be of benefit to the whole industry by tending to the production of a better product for the use of engineers.

MR. A. W. WALKER (Senior Vice-President) seconded the thanks to the guides.

MR. F. CULLEY (foundry foreman), in responding, said he had found much pleasure in answering questions during the visit.

Corrosion of Iron.

At a meeting of the American Society for Testing Materials, held at Chicago recently, MESSRS. R. F. PASSANO and F. R. NAGLEY read a Paper on "Consistent Data showing the Influence of Water Velocity and Time on the Corrosion of Iron," of which the following is a synopsis:—With temperature, oxygen concentration, composition of water, area of specimen, surface condition of specimen and composition of metal controlled, the influence of water velocity and time were studied in an immersion test, which was described. Successive experiments were conducted at intervals between one and 60 days at a velocity of 1 m. per min., between one and 30 days at 2 m. per min. and between one and 15 days at 5 m. per min. It was shown that the losses from successive experiments under the same essential conditions did not differ by more than should be left to chance. The curves showing the relation between time and average loss of weight were drawn so they did not miss the experimental values by more than the errors of the averages. Iron lost weight in direct proportion to time at the beginning of the tests. The duration of this initial period decreased as the velocity was raised, and was probably a hyperbolic function of the velocity. Following the initial period, iron loses weight in proportion to the logarithm of time under the conditions of these tests. From the relative position of the logarithmic portions of the loss-time curves, one would infer that the curves representing the various velocities would cross. Thus, the loss of weight from iron specimens increased with velocity for a time, but in the end the specimens exposed at high velocities would probably lose less weight than those exposed at low velocities.

Cast Metals and Alloys.—Under the auspices of the Association of German Foundrymen, DRS. W. CLAUS and A. H. F. GOEDERITZ have issued a comprehensive treatise dealing with foundry technology and the materials and alloys used in foundries.

North-East Coast Steel Merger.

DORMAN, LONG AND SOUTH DURHAM COMPANIES.

The terms of the scheme for the merger of Messrs. Dorman, Long & Company, Limited, and the South Durham Steel & Iron Company, Limited, have been published. A brief announcement to this effect was made in THE FOUNDRY TRADE JOURNAL last week. The scheme is conditional on the debenture and share holders of Dorman, Long & Company accepting a capital reconstruction scheme, which is put forward simultaneously with the plan for the acquisition by Dorman, Long of the South Durham and Cargo Fleet companies. Meetings of the security holders of Dorman, Long will be held on July 27 and of those of the South Durham Company on July 19 to consider the proposals.

The scheme of reconstruction involves the writing down of the share capital of Dorman, Long & Company from £11,248,146 to £1,750,678. The share capital will then again be increased to £11,248,146 by the creation of 9,497,468 new shares of £1 each, but 5,188,399 shares will remain unissued. The scheme has been based on the revaluation of the assets. The company, owing to reduced volume of trade, has been unable to earn the interest and sinking fund charges on its 5½ per cent. debenture stock and was not able to meet the interest payment due on May 1 last. A reduction of fixed interest charges is therefore necessary in order to place the amalgamated company on a stable basis. In order to allow for payments under the amalgamation, and also for new money for capital expenditure necessary for the improvement of the works, etc., the scheme provides for the creation of £2,500,000 of 5 per cent. redeemable prior lien stock, of which it is proposed to issue £2,230,000. This new stock will be repayable at par on November 1, 1973, and will be a first specific charge on the whole of the properties of the amalgamated company, subject to certain unimportant exceptions.

Debenture Changes.

Holders of the 5½ per cent. first mortgage redeemable debenture stock, are asked to surrender and cancel 10s. out of each £1 nominal amount of stock, and in respect of each £100 of stock held before such surrender to receive 30 6 per cent. preference shares of £1 each and 30 preferred ordinary shares of £1 each in the reorganised capital of the company. They are also asked to sanction the creation of the above-mentioned prior lien stock, which is to be charged on the assets to be acquired as a result of the amalgamation, and the assets forming the security for the 5½ per cent. debenture stock, and ranking in priority to that stock. The company will, however, give up the right to re-issue any of the stock surrendered except £650,000 thereof, almost all of which will be re-issued to the shareholders of the South Durham Company under the terms of the amalgamation. The charge securing the 5½ per cent. stock will be extended to cover the assets acquired under the amalgamation, but the company will be released from any obligation to bring within the specific charge any property thereafter acquired. Interest on the 5½ per cent. stock from November 1, 1932, to the date the scheme comes into operation is to be cancelled. After the latter date interest (except in respect of the stock to be re-issued) shall only be payable to the extent that there are profits available, and shall be non-cumulative. Provided that when interest at the full rate has been paid on all the stock for three consecutive financial years it shall become a fixed obligation of the company. Holders of the 5½ per cent. stock are also asked to waive their right to repayment on May 1, 1963, and to approve the cancellation of the existing sinking fund obligation and the creation of a new sinking fund to redeem the stock at par in 37 years from the end of the second financial year after the interest on the stock becomes fixed.

The scheme provides for the formation of a stockholders' committee, in whom will be vested a special management share which until the first repayment by the company to the sinking fund will confer the right on a poll to one vote in excess of the votes conferred on all the other issued shares of the company. The committee will have power to appoint a director and the members of the committee will be entitled to confer with the board on matters concerning the general policy of the company.

Arrangement with Bankers.

The trustees for the holders of the 5½ per cent. stock recommend the proposals. The bankers of the company have agreed to accept the allotment of 145,000 6 per cent. preference shares and 145,000 preferred ordinary shares of £1 each in the reorganised capital of the company in satisfaction of £290,000 of the company's indebtedness to them and will permit the balance of such indebtedness (exclusive of certain sums) to remain outstanding up to but not exceeding £1,650,000, with the benefit of certain securities at present deposited with or on behalf of the bankers. Interest will be payable on the amount outstanding at the rate of 3 per cent. per annum for the remainder of the financial year then current and for the two next financial years and thereafter at the rate of 4 per cent. per annum. The bank interest will only be payable out of profits available and will be non-cumulative until interest on the 5½ per cent. debenture stock becomes fixed. One-half of the profits available after the payment of bank interest will be used to repay the bankers, but the company will not in any year be required to repay more than 5 per cent. of the original amount permitted to remain outstanding.

The effect of the scheme on the present share capital of Dorman, Long is to reduce it from £11,248,146 to £1,750,678, while certain rights are altered. The existing preference shareholders are asked to agree to the cancellation of all dividend arrears and to the reduction in the capital value of their shares from £1 to 15s., the reduced shares being then consolidated into shares of £1 each and converted at par into new 6 per cent. preferred ordinary shares. Preferred ordinary shareholders are asked to agree to the reduction in the capital value of their shares from £1 to 2s. 6d., the reduced shares being then consolidated into shares of £1 each and converted at par into new 6 per cent. preferred ordinary shares. Ordinary shareholders are asked to agree to the reduction in the capital value of their shares from £1 to 2s., the reduced shares being then consolidated into shares of £1 each and converted at par into deferred ordinary shares. As regards the rights of the new preference, preferred ordinary and deferred ordinary shares, the dividend on the preference shares will be non-cumulative and in a winding-up the shares will, in addition to their preferential right to repayment of capital, be entitled to share with the preferred ordinary and deferred ordinary shares in any surplus assets available after the repayment of the capital of those shares. The dividend on the preferred ordinary shares will be at the rate of 6 per cent. and after payment thereof any available profits will be distributed among the holders of the preferred ordinary shares and deferred ordinary shares *pari passu* in proportion to the capital for the time being paid up on the shares of each of such classes held by them.

Terms of the Merger.

The terms of the amalgamation with the South Durham Company provide for redemption in cash of the £300,000 4½ per cent. debenture stock of that company, and the £130,100 4½ per cent. debentures and the £496,500 6 per cent. "A" debentures of the Cargo Fleet Iron Company (which is controlled by the South Durham Company). With regard to the shareholders of the South Durham Company, holders of the £300,000 of 6 per cent. cumulative preference share capital receive cash at par for their shareholdings, and in addition, having regard to their rights in surplus assets, one preferred ordinary share of the reconstituted company for every two preference shares held. Holders of the £350,000 of ordinary share capital in respect of each share held, receive £1 of 5½ per cent. "A" first mortgage redeemable debenture stock in the reconstituted company, and in respect of their right of participation in surplus assets three preferred ordinary shares of the reconstituted company for every four ordinary shares held. Holders of the £587,820 of "B" ordinary share capital, in respect of each share held, receive 10s. in the 5½ per cent "A" first mortgage redeemable debenture stock, and in addition four 6 per cent preference shares and three preferred ordinary shares in the reconstituted company for every eight "B" ordinary shares held. The sums required for the debenture and share capital repayments, above-mentioned, amount to £1,287,930, and will be provided out of the proceeds of the issue of the 5 per cent. redeemable prior lien stock. The balance, less any expenses, of this issue will be available for the general purposes of the reconstituted company.

The Board of Directors.

The board of Messrs. Dorman, Long & Company will be reconstituted as follows:—Mr. Charles Mitchell (chairman), Mr. Benjamin Talbot (deputy chairman), the Hon. R. D. Kitson (vice-chairman), Mr. A. Dorman (vice-chairman), Mr. J. H. B. Forster, Sir M. Lowthian Bell, Mr. C. L. Dalziel, Mr. Lawrence Ennis, Mr. J. G. Goodenough, Mr. W. L. Johnson, the Hon. H. D. McLaren, Mr. A. N. McQuistan, Mr. J. B. Peat, Mr. B. Walmsley, and such person as shall be appointed by the debenture stockholders' committee. A Chairman's Advisory Committee is to be created, consisting of the chairman, deputy chairman, vice-chairman, and Mr. J. H. B. Forster. The duties of this committee will be the supervision of the business and internal management and administration of the company, and the consideration and approval of any proposals of any other committee of the board of directors.

In a letter to the shareholders and debenture holders of Dorman, Long & Company, the directors point out that the result of the agreement to acquire the assets of the South Durham Steel & Iron Company will be to bring under unified control practically the whole of the iron and steel industry on Tees-side, as the latter company owns 98 per cent. of the share capital of the Cargo Fleet Iron Company, Limited.

The South Durham Steel & Iron Company, Limited, in a circular to their shareholders, state that the amalgamation will prevent competition and eliminate obsolete or redundant plant and secure the progressive concentration of production in the more efficient plants with resultant savings in costs and a more effective selling organisation.

THE MERGING COMPANIES.

Dorman, Long & Company, Limited, were first registered in 1889, and in 1923, by a reorganisation of their subsidiary companies, they took over the entire properties and plant of Bell Bros., Limited, the North Eastern Steel Company, Limited, Sir B. Samuelson & Company, Limited, and the Carlton Iron Company, Limited. In November, 1929, an amalgamation was effected with Bolckow, Vaughan & Company, Limited.

The share capital of the company is £11,248,146, of which £2,052,746 is in 8 per cent. non-cumulative preferred ordinary shares, £883,918 in 6 per cent. cumulative preference shares of £1 each, and £8,311,482 in £1 ordinary shares. The debenture stock is (*a*) £400,000 4 per cent. first mortgage perpetual debenture stock and (*b*) £5,228,721 5½ per cent. first mortgage redeemable debenture stock (outstanding at September 30, 1932). The directors of the company are: Mr. Charles Mitchell (chairman), Hon. R. D. Kitson (deputy-chairman), Mr. Arthur Dorman (vice-chairman), Colonel Sir Maurice L. Bell, Bt., Hon. H. D. McLaren, Mr. Ben Walmsley, Mr. C. D. Dalziel, Mr. Lawrence Ennis, Mr. I. L. Johnson, Mr. W. L. Johnson, Mr. Francis Samuelson, and Mr. J. B. Peat.

The company produces pig-iron, ferro-manganese and spiegeleisen; steel blooms and billets, steel plates, joists, channels, angles, tees, flats, rails and fishplates, rods, wire, galvanised and black sheets; coke, tar, benzol, and other coal by-products. The company are shippers of coal and coke from their own staith on the Tees. The company has an annual productive capacity of 1,700,000 tons of steel ingots, 1,385,000 tons of finished steel, 1,500,000 tons of pig-iron, 3,500,000 tons of coal, and 2,500,000 tons of ironstone. Their works are: Britannia Steel Works, Middlesbrough; Cleveland Iron & Steel Works, South Bank; Bridge & Constructional Works, Middlesbrough; Redcar Iron & Steel Works; Clarence Iron & Steel Works; Acklam Iron & Steel Works; Newport Ironworks; Ayrton Sheet Mills; Cleveland Wire Mills; London Constructional Works, Nine Elms.

South Durham Steel & Iron Company.

The South Durham Steel & Iron Company, Limited, are the largest manufacturers of steel plates in England, having a steel plate capacity of 8,000 tons per week. Their capital is £1,237,820, and there is £300,000 4½ per cent. debenture stock. The capital of the Cargo Fleet Company is £1,000,000, of which 98 per cent. is held by the South Durham Company. The debenture debt is £130,100 4½ per cent. first mortgage debentures and £496,500 6 per cent. "A" debentures.

XUM

Fuel Problems of the Swedish Iron and Steel Industry.*

By Prof. Arvid Johansson.†

Production of Pig-Iron. Charcoal.

The main part of Swedish pig-iron is produced in blast furnaces with pinewood charcoal as the only fuel. In the electric pig-iron furnace, some of the charcoal is replaced by electric energy, and the charcoal consumption is here only 45 to 50 per cent. of that in the blast furnace. The future development of electric pig-iron smelting will depend upon the state of the market and the price of electric power. During the last decades the price of charcoal has shown a steady increase, principally because the kind of wood formerly used exclusively for charcoal production must now be shared with the wood-pulp industry. This competition seems, however, now to have reached a certain equilibrium. During the years before the world war the annual charcoal consumption of the Swedish iron and steel industry was somewhat above 4,000,000 cub. m., but it has now dropped considerably below half that figure.

About 15 per cent. of the charcoal is produced in stationary by-product ovens, while about 85 per cent. is still obtained from charring heaps. About 30 per cent. of the wood charred in ovens and about 20 per cent. of that in heaps consists of waste material from the saw mills. As, however, this wood is to an increasing extent being absorbed by the wood-pulp industry, it will be necessary to calculate in the future with a reduced amount of this so-called lath coal. Some lath coal is imported from Finland. With a view to improving the economy of the charcoal production in ovens, research has for a number of years been carried on at the charcoal laboratory of Ingeniörsvetenskapsakademien (the Royal Swedish Institute for Engineering Research). The expenses have been defrayed by the said institute, by Jernkontoret (The Swedish Iron Masters' Association) and by a big charcoal company. The work includes better yield of by-products and their refinement into more valuable products. Some good results have already been obtained.

Direct Methods of Iron Production.

For the production of high-quality steel in Sweden only pig-iron made with charcoal as exclusive fuel and scrap originating from such pig-iron is used. As the supply of such scrap is not sufficient, much more pig-iron is used in the most important steelmaking process, *i.e.*, the acid open-hearth process, than is really consistent with real economy. Sweden is therefore very much interested in the attempts to produce so-called iron sponge, made by direct reduction from ore, at a price lower than that of charcoal pig-iron. Since 1911 iron sponge has been produced at Höganäs in Skane from Gellivare concentrates. It contains about 95 per cent. of iron, 0.010 per cent. phosphorus and max. 0.020 per cent. sulphur. In spite of its high price this iron sponge is used to a certain extent by some steel plants.

During the last years considerable experimental work has been done on new methods of producing iron sponge. Of these Wiberg's and Ekelund's processes use reduction with gas, while in Kalling's process solid carbon is the reducing agent. In Wiberg's process a certain part of the reducing gas is regenerated in an electrically-heated charcoal producer, while in Ekelund's process the gas is obtained from a producer fired with coal and coke. In Kalling's process the pulverised mixture of ore and coal is heated to reaction temperature by electric current. No full-size plants for these new processes have yet been built. From the calculations and half-scale experiments it is, however, evident that it will be possible to obtain a cheap sponge which, when melted in electric furnaces with a lower percentage of pig-iron than that now used in the acid open-hearth process, will give a high-grade steel.

Steel Production by the Open-Hearth Process.

In the basic open-hearth furnace ordinary qualities of steel are principally produced, to be sold on the home market as machine and structural steel. The fuel for this type of furnace is producer gas from imported fossiliferous coal. In the acid open-hearth furnace, where, as already mentioned, mainly high-grade steel of the tool-steel type and low-alloyed special steels are produced, the fuel used has of old been producer gas from wood or peat, in order to keep the sulphur content of the steel at a minimum. In certain cases, where the sulphur content is of less importance, coal is also used. As additional fuel for the open-hearth, blast-furnace gas is used when available. About 20 per cent. of the producer gas may be saved in this way. To keep the furnace warm during standstills the blast-furnace gas may be used alone.

The gas from the electric pig-iron furnace contains only a small percentage of nitrogen and has a calorific power of about 2,200 kcal. per cub. m. This gas may be used as principal fuel for the open-hearth furnace. A small percentage of producer gas from coal or wood is added, and in order to obtain an incandescent flame and thereby increase the heat transfer, tar is injected by means of water vapour during certain periods of the metallurgical process.

The heat content of the flue gas from the open-hearth furnace is at some steel plants utilised for generating steam. This steam is in the first place used at the furnace as addition to the air for the gas producers, and further for the heating of adjacent localities, etc. As the open-hearth furnaces are small, generally with a charge of 15 to 20 tons, and in comparison with foreign furnaces are worked fairly slowly, the heat content of the flue gases which can be utilised is comparatively small. When the gas producers are wood fired, the flue gas is used for drying the wood as well as for heating the producer air. A temperature of 200 deg. C. on the producer air is beneficial to the gas-producing process, as the gas obtained has a lower content of carbonic acid and a higher content of hydrogen. For the production of 1 ton of steel the consumption of wood is 2.1 to 2.3 cub. m.

Heating of Steel for Rolling, Forging and Annealing.

The fuel for the heating furnaces is coal, which is charged into producers directly connected to the furnace. Sometimes, however, the furnaces are fed with gas from a battery of producers. While older constructions with intermittent charging of coal are still in general use, a new construction has been introduced during the last decade with continuous charging of fuel as well as continuous drawing of the slag. It gives a gas with a very uniform composition and temperature, and is very labour-saving. Attempts have been made to fire these furnaces with electric-furnace gas. This gas, however, burns slowly, and the temperature obtained in the back part of the preheating chamber is high. This is of advantage when soft steel is heated, as the capacity of the furnace per square metre of hearth surface increases. For heating hard steel this gas may, however, not be used, as the material will be too much decarburised. The flue gas leaving the forging furnaces has a temperature of about 1,000 deg. C. and part of its heat content is therefore generally utilised in a boiler for producing steam. The heating furnaces for rolling are constructed as push furnaces on the counter-current principle, and the temperature of the flue gas is therefore too low to enable its utilisation in boilers. In some cases it is used for pre-heating the secondary air, whereby combustion is facilitated and better fuel economy is obtained. In certain cases, as when Lancashire iron is welded, it is necessary to raise the temperature of the secondary air to about 200 to 300 deg. C. in order to obtain sufficient welding heat in the furnace. The most modern air heaters are made of heat-resisting chromium-steel tubes, about 75 mm. in dia., folded in meanders and placed in a chamber below the back end of the furnace.

For the annealing of steel castings, plates, etc., furnaces with a movable hearth are used, fired with producer gas from wood or coal. For the low annealing of carbon steels with higher carbon contents as well as of alloyed steels such as ball-bearing steel, blast-furnace gas or producer gas was formerly used. On account of its low calorific power the former gas was found very suitable. Nowadays mainly electric furnaces are installed.

Electric Power as a Source of Heat.

The first important employment of electricity in the Swedish iron and steel industry was for the electric smelting of pig-iron. The construction of the A. B. Elektrometall's electric pig-iron furnace is intimately connected with the precarious position of the charcoal problem 25 years ago. On the basis of experiments at Domnarfvet in 1907 to 1909 a full-size experimental furnace was built by Jernkontoret at Trollhättan in 1910. Several Swedish works here smelted their ore mixture, and the results obtained were promising also from the point of view of quality. The furnace was afterwards bought by an adjacent steelworks, and somewhat later a second furnace was built in the same place. Then followed in the years 1912 to 1917 the erection of five furnaces at Hagfors, in 1912 to 1919 four furnaces at Domnarfvet, in 1914 one furnace at Söderfors, in 1918 two furnaces at Porjus and finally in 1932 one furnace at Degerfors. Of these only the furnaces at Hagfors, Domnarfvet and Degerfors are at present in use.

The world war and its consequences have checked the development of the electric pig-iron furnace. As mentioned above the main interest has of late years instead been devoted to the lowering of the charcoal consumption in the ordinary blast furnace. This work has been so successful that under present conditions there is no reason to push electric pig-iron smelting. This way will, of course, always be open if once again the scarcity and high price of charcoal forces the steel industry to reduce their claims on the forest resources.

Electric steel production gains more and more ground, and will probably continue to do so at a still faster rate if the smelting in high-frequency induction furnaces redeems its promises. Such furnaces have now been installed in sizes up to 4- to 5-ton charges for refining a mixture of pig-iron, scrap and iron sponge to high grade steel. Quite definite results have, however, not yet been obtained. For the production of ordinary merchant steel, the electric-arc furnace intrudes more and more on the domains of the basic open-hearth furnace. At the largest Swedish steelworks for merchant steel, Domnarfvet, most of the steel is now produced by the basic-Bessemer process, some part being refined in 25- to 30-ton electric-arc furnaces. Those furnaces are also used for scrap smelting.

For the heating of steel to be hot-rolled or forged, electricity has not yet been used, and any development in that direction is hardly probable

(*Concluded on following page.*)

* From a Paper read before the World Power Conference Sectional Meeting in Scandinavia.

† Chief Engineer, Jernkontoret (Swedish Iron Masters' Association), Stockholm.

This Week's News in Brief.

Trade Talk.

PLANS FOR PROPOSED ADDITIONS to Messrs. Flavel's Eagle Foundry, in Clarence Street, Leamington, have been approved by the Highways Committee of the Leamington Town Council.

LORD STONEHAVEN, President of the Institution of Naval Architects, has consented to serve as President of the Shipping and Engineering Exhibition in the place of the late Lord Wester Wemyss. The exhibition will be opened at Olympia on September 7.

A FIRE BROKE OUT on Saturday afternoon in the ironfoundry of Messrs. Charles W. Taylor & Son, Limited, Templetown, South Shields. The flames, which were confined to the stacks of patterns, mainly for marine-engine parts, were quickly extinguished by the local fire brigade.

MESSRS. RICHARDSONS WESTGARTH-BROWN BOVERI, LIMITED, have appointed Mr. H. S. Lewis, of Birmingham, formerly Midlands representative of Richardsons, Westgarth & Company, Limited, as sales manager, with headquarters at the London office of the company, 56, Victoria Street, S.W.1.

A FACTORY FOR THE manufacture of razor blades started operations last week in Glasgow, under the control of William Wylie, Limited. It is expected to produce for the Colonies as well as for the home market. The directors anticipate that orders formerly placed in Germany will be obtained by them.

MORE THAN six months' work will be given to the Central Marine Engine Works of Messrs. William Gray & Company, Limited, West Hartlepool, by the decision of Messrs. R. Ropner & Company, Limited, the West Hartlepool shipowners, to have the engines of 14 of their fleet of cargo vessels reconditioned.

SHEFFIELD CITY COUNCIL recently approved of a contract to supply 50,000,000 units of electricity a year through their electricity department to Messrs. Thomas Firth & John Brown, Limited. The supply will be taken from the national grid. Messrs. Thomas Firth & John Brown, Limited, have agreed to scrap their own generating stations.

MR. EDWIN F. ORR, of Melbourne, who is visiting this country, wishes to get into touch with manufacturers of engineering machinery, hardware, machine tools, etc., on an agency basis. He is returning to Australia in August or September. Letters should be addressed, in the first place, to the Commercial Officer, Australia House, Strand, W.C.2.

MESSRS. YARROW & COMPANY, LIMITED, Scotstoun, Glasgow, have contracted to construct the boilers for three train ferries ordered by the Southern Railway Company from Messrs. Swan, Hunter & Wigham Richardson, Limited, Newcastle-upon-Tyne. The boilers will be of the latest Yarrow type for burning coal equipped with Taylor retort-type stokers.

GLASGOW TRANSPORT COMMITTEE have agreed to place contracts for tram rails and other materials to the value of £24,552. An order for 3,000 tons of tram rails will be divided between Dorman, Long & Company, Limited, and Skinningrove Iron Company, Limited. The water department has placed a £3,094 contract for 398 tons of cast-iron pipes with Messrs. Cochrane & Company, Limited.

MESSRS. GLENFIELD & KENNEDY, LIMITED, Kilmarnock, have just completed the construction of two large Venturi meters for the Grampian hydro-electric scheme. The tubes have been delivered for installation at the Tummel Power House. They will be used for recording the water passing through the pipes and connected to drum-type recorders. The tubes are among the largest ever constructed, weighing over 9½ tons apiece.

THE WORKS OUTING of the Suffolk Iron Foundry, Stowmarket, was held on Saturday, July 8, when upwards of 150 employees travelled to Yarmouth, where they were joined by Mr. L. Tibbenham, managing director, Mr. R. Marland and Mr. W. Taylor. Following an excellent lunch, Mr. Taylor proposed a vote of thanks to the management for their support and co-operation in the welfare of their employees. Mr. Tibbenham responded. He referred to the enormous growth of the firm during recent years, and was warmly applauded when he stated that large contracts had been placed with the firm. He spoke of the recent appointment of Mr. R. Marland, who was most anxious to see 1,000 employees at the Stowmarket factory before long, and mentioned the fact that their Birmingham works were now being moved to Stowmarket.

Fuel Problems of the Swedish Iron and Steel Industry.

(Concluded from previous page.)

in the near future. On the other hand, the importance of electrical annealing furnaces is rapidly increasing, especially for the heat-treatment of cold-worked material such as band and wire. The furnaces are simple and easy to start, and the working expenses are low. A protective gas to prevent decarburisation may be used in these furnaces. Electric furnaces are also suitable for heating steel which is to be quenched. Table I gives the consumption of electrical energy for smelting purposes in the Swedish iron and steel industry.

TABLE I.—*Consumption of Electrical Energy for Smelting Purposes in Swedish Iron and Steel Industry.*

Year	Pig-iron kw.-hrs.	Steel* kw.-hrs.	Ferro alloys, kw.-hrs.
1920 ..	175,5.10⁶	not specified	100,6.10⁶
1921 ..	152,5.10⁶	not specified	47,7.10⁶
1922 ..	100,0.10⁶*	not specified	105,9.10⁶
1923 ..	132,2.10⁶*	25,9.10⁶	124,9.10⁶
1924 ..	232,7.10⁶*	36,1.10⁶	145,4.10⁶
1925 ..	218,8.10⁶*	37,0.10⁶	213,0.10⁶
1926 ..	212,2.10⁶*	34,9.10⁶	225,0.10⁶
1927 ..	191,1.10⁶*	51,1.10⁶	280,0.10⁶
1928 ..	188,2.10⁶*	68,6.10⁶	333,0.10⁶
1929 ..	218,2.10⁶*	86,5.10⁶	294,4.10⁶
1930 ..	226,9.10⁶*	84,4.10⁶	291,6.10⁶

* Approximate figures.

The Swedish iron and steel industry has during recent years continued to invest capital in order to augment the supply of electric energy, which has been done in the conviction that the consumption of such energy within the iron and steel industry will continue to increase for smelting as well as for heat-treating purposes.

New Companies.

C. & B. Smith, Limited.—Capital £40,000. Ironfounders. Directors: C. R. Smith, 127, Tettenhall Road, Wolverhampton; A. B. Smith.

S. C. Gresswell & Company, Limited.—Capital £2,000. Manufacturers of gunmetal steam fittings or parts. Director: S. C. Gresswell, 190, Ulverley Green Road, Olton, Birmingham.

Allen & Greaves, Limited, 13 and 15, Old Queen Street, S.W.1.—Capital £3,000. Ironmasters, iron and brass founders, steel makers, etc. Directors: A. A. Ospalak, D. Ospalak, M. Pitter, W. J. Allen and A. H. Greaves, 52, Thornhill Road, Leyton.

Diamond Foundry Company, Limited.—Capital £100. Manufacturers of cooking and heating appliances, stoves, furnaces, etc. Subscriber: K. N. Davis, Apple Tree House, Park Avenue, Harpenden.

London Welding Company, Limited.—Capital £2,000. Electric-arc and oxy-acetylene cutters and welders, etc. Directors: T. McLellan, Hill Farm, Witnesham, Suffolk; J. Crighton and P. W. B. Crighton.

Contracts Open.

Cork, July 15.—20 tons of 4-in. cast-iron water pipes, also special castings and sluice valves, for the Corporation. The Waterworks Office, Fitzgerald Park, Cork.

London, N., August 9.—High-tension switchgear and accessories, for the Islington Borough Council. The Borough Electrical Engineer, 60, Eden Grove, Holloway, N.7.

Helsingfors.—1,000 tons of cast-iron machinery scrap for furnace charge for a local firm. The Department of Overseas Trade. (Reference G.Y. 12770.)

Personal.

MR. A. G. FOSTER has been appointed general sales manager of Messrs. Kryn & Lahy (1928), Limited, engineers and steelfounders, of Letchworth.

MR. JAMES GRAY, of Wishaw, has retired after completing 62 years of continuous service with the Coltness Iron Company, Limited, Newmains.

MR. ARCHIBALD WILSON, general manager of the Sanquhar and Kirkconnel works of Messrs. Bairds & Dalmellington, Limited, has retired after 29 years' service with the company.

MR. AND MRS. JAMES GILLESPIE, of Motherwell, have just celebrated the fiftieth anniversary of their marriage. Mr. Gillespie was for many years chief engineer in the Dalzell steelworks of Messrs. David Colville & Company, a post from which he retired a few years ago.

MR. T. W. GRAHAM, manager of the Workington iron and steel works of the United Steel Companies, Limited, retired recently, after nearly half a century spent at the same works. He will be succeeded by MR. W. L. JAMES, of the Templeborough Works, Rotherham.

MR. F. BLAND, who has been in charge of the track-work department of Messrs. Edgar Allen & Company, Limited, Imperial Steelworks, Sheffield, is retiring. At the annual meeting of the company recently the chairman referred to the valuable services rendered by Mr. Bland during his 30 years' association with the business, and tendered to him the good wishes of the board and his colleagues. Mr. Bland's services will be retained by the company in a consultative capacity.

Wills.

JACKSON, MAJOR COLIN MACKAY, R.E., engineer, managing director of Messrs. J. H. Carruthers & Company, Limited, Polmadie, Glasgow £102,128

ASQUITH, J. W. S., of Skircoat, Halifax, head of Messrs. William Asquith, Limited, and a director of the Associated British Machine Tool Makers, Limited £64,624

Company Reports.

Brightside Foundry & Engineering Company, Limited.—The directors have decided to defer payment of the dividend on the 5 per cent. preference shares.

W. T. Henley's Telegraph Works Company, Limited.—Profit, £300,298; brought in, £557,495; directors' and auditors' fees, debenture interest, and written off for depreciation of buildings, machinery, etc., £71,989; income tax, £13,387; dividend on the 4½ per cent. preference shares to December 31 last, £9,000; interim dividend on ordinary shares, £48,750; to reserve against trustee securities, £1,516; to reserve account, £50,000; available, £663,151; final dividend on the ordinary shares of 2s. 6d. per share, making 4s. for the year, and a cash bonus of 2s. per share, £146,250; carried forward, £516,901.

Obituary.

MR. ALBERT HADDON, a partner in the firm of Robert Saunders (Castings), Limited, brassfounders, of Wiilenhall, died recently.

MR. THOMAS E. EVANS, of Cardiff Road, Llandaff, metal merchant and representative for Messrs. Charles Tennant, Sons & Company, Limited, Merchants' Exchange, Cardiff, died suddenly on Friday, June 30.

MR. GEORGE HATTON, J.P., of Hagley House, Stourbridge, a director of the Earl of Dudley's Round Oak Works, Limited, Brierley Hill, died on Sunday, July 2, in London. Mr. Hatton, who was 82 years of age, was a prominent figure in the iron and steel trades of the Midlands, being a past-president of the Dudley Chamber of Commerce, a member of the Staffordshire Iron and Steel Institute, and a chairman of the Midland Wages Board associated with the iron and steel trade. When a young man he was with his father, who was head of the firm of Hatton, Sons & Company, tinplate manufacturers, of Bilston. For over 40 years he was associated with the Earl of Dudley's Round Oak Works, originally as secretary, later as managing director, and of recent years as a director.

XUM

Raw Material Markets.

Although there has not been a great deal of fresh booking lately in the pig-iron markets, due to holiday interruptions, contract deliveries have been well maintained in view of the season. The outlook in the home semi-finished steel trade is much more promising since the imposition of tariffs on foreign material. The demand for finished steel is still limited, being adversely affected by the depression ruling in the shipbuilding industry and in many sections of the heavy engineering trades.

There is a steady demand for scrap-iron, light metal particularly being in favour.

Pig-Iron.

MIDDLESBROUGH.—The lack of export business is more than compensated for by the maintenance of an active home demand. The output of Cleveland pig-iron is being fully absorbed, and deliveries are having to be made from stock. Owing to the greater activity at the associated steelworks, a blast-furnace has had to be restarted at the Cargo-Fleet Works on basic iron. There are now 19 furnaces in production on the North-East Coast. New prices are now in operation for Middlesbrough iron for delivery in Scotland. The delivered prices are:—Middlesbrough area, 62s. 6d.; North-East Coast, 64s. 6d.; Glasgow area, 65s. 3d.; Falkirk area, 62s. 3d. No. 1 foundry iron is at a premium of 2s. 6d. per ton, and No. 4 foundry and No. 4 forge at a discount of 1s. External sources of pig-iron supply are now almost closed.

The East Coast hematite market is in a strong position. Further large sales have been made, chiefly to Sheffield and South Wales, and one local firm is reported to be fully sold until the end of September. In these circumstances, hopes are expressed of the eventual liquidation of the heavy standing stocks that have been a feature of the market for such a long time. Prices are firmly quoted at 59s. per ton for mixed numbers and 59s. 6d. for No. 1 quality.

LANCASHIRE.—The consumption of pig-iron in Lancashire is fairly well maintained, in view of the season of the year. Deliveries against running contracts are being made in fair volume, although the usual holiday interruptions are now being experienced. One or two of the general foundries are rather better employed, textile machinery remaining the worst section in this respect. For delivery to users in the Manchester area, current offers of Staffordshire, Derbyshire and North-East Coast makes of No. 3 iron are on the basis of 67s. per ton, with Northants at 65s. 6d., Derbyshire forge at 62s., Scottish foundry at about 80s., and East and West Coast hematite at about 75s. and 80s. respectively.

MIDLANDS.—The volume of new bookings has fallen away, as most of the bigger consumers have already covered their needs up to the end of September (even further in some cases), at current rates—66s. for Derbyshire, Staffordshire and North Lincolnshire No. 3, and 62s. 6d. for Northants No. 3, delivered South Staffs. Present deliveries of pig-iron are at a good level for the month of July. Continental foundry-iron is not competitive in this area. A small amount of Cleveland comes in at 66s. per ton, delivered. Local motor and engineering trades are importing fair quantities of special foundry-irons from other parts of the country. In this respect refined iron is quoted at from £5 to £6 15s., and medium and low-phosphorus irons at from 70s. to 90s. per ton, delivered Black Country stations. No. 3 Scottish is at 83s. 6d. to 85s. per ton.

SCOTLAND.—Scottish foundry-iron remains at the official minimum of 65s. for No. 3, f.o.t. furnaces, with an additional 2s. 6d. for No. 1 quality. Quotations for Cleveland iron are now at 65s. 3d. for No. 3 f.o.t. Glasgow and 62s. 3d. f.o.t. Falkirk. Little business has so far been done at the new prices, as the Falkirk foundries closed down last week for a ten-day holiday, whilst the Glasgow Fair holidays are also just due.

Coke.

The situation in the foundry-coke market shows no change, consumers still being content to buy on hand-to-mouth lines. Current quotations are as follow:—Best Durham coke, 36s. 6d. to 38s. per ton; Scottish low-ash coke, 39s. to 40s.; Welsh coke, 30s. to 45s., according to analysis, delivered in the South Staffordshire area.

Steel.

Although the holiday season is approaching, when the demand from consumers usually declines, the volume of business is on a fairly satisfactory scale, according to the official report of the London Iron and Steel Exchange. In the semi-finished steel department some sales of Continental semis have been reported at figures well below the European Steel Cartel's quotations for other markets. These were the first sales of foreign material of importance for some time, and attracted considerable interest. British works producing semis are well employed, as until recently they have experienced practically no competition in their own market. In the finished-steel section business in the home market continues active, but conditions vary in the different districts. This week the home trade has been disturbed by offerings of Belgian steel at competitive prices. In some departments contracts are being completed, and are not being replaced quickly enough to keep the works well employed. The general demand, however, appears to be growing in volume, although it is still confined to small quantities, and there is little forward booking.

Scrap.

On the whole, the demand for scrap iron is well maintained throughout the country. In the Cleveland area deliveries of heavy and machinery metal are somewhat restricted, but there is a good call for light metal from local foundries. Steady conditions rule in the Midlands market. In South Wales there is a slightly steadier demand for both heavy and light grades of scrap-iron, and prices are firmer, but the call for machinery is still very weak. A feature of the Scottish market is the difficulty of disposing of machinery cast-iron scrap at current quotations.

Metals.

Copper.—After some hesitation towards the end of last week, the copper market continued its upward rise, standard quotations rising on Monday to £39 a ton. Electrolytic metal was at about 9.00 cents per lb c.i.f., or a sterling equivalent of £43 a ton. This firmness in the market must be largely accounted for by the general flight from currencies into commodities; a tendency which has been most marked on the Continent, where serious doubts are held as to the financial stability of some of the "gold" countries. A movement of this character, however, must inevitably have some future repercussion upon prices.

Buying by consumers has been rather limited lately, especially in Europe, but favourable reports are received from the U.S.A., where the inflationary movement continues its progress. General consumption of copper in the United States is stated to be showing a gradual improvement.

The week's prices have been as follow:—

Cash.—Thursday, £38 15s. to £38 17s. 6d.; Friday, £38 13s. 9d. to £38 15s.; Monday, £38 18s. 9d. to £39; Tuesday, £37 16s. 3d. to £37 18s. 9d.; Wednesday, £38 11s. 3d. to £38 12s. 6d.

Three Months.—Thursday, £38 18s. 9d. to £39; Friday, £38 16s. 3d. to £38 17s. 6d.; Monday, £39 1s. 3d. to £39 2s. 6d.; Tuesday, £38 to £38 2s. 6d.; Wednesday, £38 15s. to £38 16s. 3d.

Tin.—In their weekly report, Messrs. Rudolf Wolff & Company state that the statistics published last week, although perhaps not quite up to fullest expectations, were nevertheless favourable, and the decrease in the total visible supply of about 2,200 tons stimulated a rather more active interest on the part of buyers. Business with consumers continues quiet, both in this country and on the Continent, and similar conditions have obtained in the United States of America, where buying has been to some extent restrained by the uncertainties surrounding the financial situation and the instability of foreign exchanges. The undertone meanwhile remains firm, but rather quieter conditions have on the whole prevailed, due in a large measure to the uncertain outlook, and what may be the outcome of the present position in America. There would seem, however, to be little prospect of any material setback, providing restricted output is still enforced and stocks are reasonably controlled, but further sustained advance must depend on how the general situation develops and to what extent consumption continues to improve.

Daily quotations:—

Cash.—Thursday, £223 5s. to £223 10s.; Friday, £221 10s. to £221 15s.; Monday, £215 15s. to £216; Tuesday, £211 10s. to £211 15s.; Wednesday, £217 15s. to £218.

Three Months.—Thursday, £222 10s. to £222 15s.; Friday, £221 5s. to £221 10s.; Monday, £215 15s. to £216; Tuesday, £211 5s. to £211 10s.; Wednesday, £217 12s. 6d. to £217 15s.

Spelter.—The spelter market prevents a very firm appearance, prices continuing to improve. Consumption of this metal is reported to be still moving upwards, a little more business having been done recently with the brass and zinc sheet industries. In view of the continued decrease in the stocks of the Cartel, the question of an increased output is being raised, but it is thought that producers will prefer to wait a while until there has been a more general increase in activity in the consuming trades.

Price fluctuations:—

Ordinary.—Thursday, £18 5s.; Friday, £18 10s.; Monday, £18 11s. 3d.; Tuesday, £17 17s. 6d.; Wednesday, £18 3s. 9d.

Lead.—Although there has been a fair amount of buying recently, little of it has been to the account of consumers. Messrs. Henry Gardner report that the market "has moved in sympathy with the others, but lacks resiliency." There has been a slight improvement in conditions in the cable-manufacturing industry.

Daily market prices:—

Soft Foreign (Prompt).—Thursday, £13 15s.; Friday, £13 16s. 3d.; Monday, £13 12s. 6d.; Tuesday, £13 6s. 3d.; Wednesday, £13 11s. 3d.

Messrs. Bruce Peebles & Company, Limited, announce that their works will close for the Edinburgh trades holiday on Friday evening, July 21, and reopen on Monday morning, July 31.

CAST IRON FLANGED PIPES
2 in.–12 in. & CONNECTIONS. to 24 in. dia.
WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.
JAMES & RONALD RITCHIE, LTD.,
Telephone: 3852 (2 Lines). MIDDLESBROUGH. Telegrams: "Ritchie, Middlesbrough."

FOUNDRY BOXES

...that speed up production for the Modern Foundry—

One of the greatest improvements you can introduce into your foundry is the STERLING ROLLED STEEL MOULDING BOX . . . . the result is speed and economy all round. Your moulders will put down more moulds per day because of the light and easy handling properties of these boxes.

You will be sure of producing accurate castings because STERLING BOXES maintain their accuracy permanently. Also your moulding costs will be halved—STERLING BOXES stand up to heavy service, anywhere.

Sterling

UP-TO-DATE

MOULDING BOX EQUIPMENT

Save their cost in a few months, and are obviously a sound investment for any foundry.

STERLING FOUNDRY SPECIALTIES LTD.,

WORKS— BEDFORD.

LONDON OFFICE:— 13, VICTORIA STREET, S.W.1.

Agents at GLASGOW and MANCHESTER

RAW MATERIALS—PRICE LIST.

(Wednesday, July 12, 1933.)

COPPER.

	£	s.	d.
Standard cash	38	11	3
Three months	38	15	0
Electrolytic	42	0	0
Tough	40	0	0
Best selected	40	10	0
Sheets	68	0	0
India	50	10	0
Wire bars	42	10	0
Ingot bars	42	10	0
H.C. wire rods	44	10	0
Off. av. cash, June	36	16	1⅝
Do., 3 mths., June	37	0	0⅝
Do., Sttlmnt., June	36	16	3⅝
Do., Electro, June	41	8	9⅝
Do., B.S., June	40	3	0⅝
Do., wire bars, June	41	17	7⅝
Solid drawn tubes			10½d.
Brazed tubes			10½d.
Wire			7d.

BRASS.

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8⅞d.
Rods, extd. or rlld.	8d.
Sheets to 10 w.g.	8½d.
Wire	8d.
Rolled metal	7½d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5¾d.

TIN.

	£	s.	d.
Standard cash	217	15	0
Three months	217	12	6
English	219	0	0
Bars	220	5	0
Straits (nom.)	222	10	0
Australian (nom.)	—		
Eastern	222	15	0
Banca (nom.)	222	10	0
Off. av. cash, June	220	1	8
Do., 3 mths., June	219	15	7½
Do., Sttlmt., June	220	2	1½

SPELTER.

	£	s.	d.
Ordinary	18	3	9
Remelted	17	15	0
Hard	15	0	0
Electro 99.9	20	10	0
English	18	12	6
India	16	15	0
Zinc dust	20	0	0
Zinc ashes	3	15	0
Off. aver., June	16	17	7⅜
Aver. spot, June	16	19	9½

LEAD.

	£	s.	d.
Soft foreign ppt.	13	11	3
Empire	13	16	3
English	15	0	0
Off. average, June	13	8	6½
Average spot, June	13	5	7½

ALUMINIUM.

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	26	0	0
Do., V.M. ex-whse.	25	10	0
Rods	30	0	0

ANTIMONY.

	£	s.	d.	£	s.	d.
English	37	10	0 to	40	0	0
Chinese				27	0	0
Crude					—	

QUICKSILVER.

	£	s.	d.	£	s.	d.
Quicksilver	8	15	0 to	9	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon—	
25%	£6 10 0
45/50%	£12 10 0
75%	£18 2 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free of Mo.	6/3 per lb.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£15 0 0
Ferro-tungsten—	
80/85%	1/6 lb.
Tungsten metal powder—	
98/99%	1/9 lb.
Ferro-chrome—	
2/4% car.	£25 10 0
4/6% car.	£21 17 6
6/8% car.	£19 7 6
8/10% car.	£18 17 6
Ferro-chrome—	
Max. 2% car.	£30 0 0
Max. 1% car.	£31 0 0
Max. 0.70% car.	£42 10 0
70% carbon-free	10½d.
Nickel—99.5/100%	£225 to £230
"F" nickel shot	£202 10 0
Ferro-cobalt	5/9 lb.
Aluminium 98/99%	£100 0 0
Metallic chromium—	
96/98%	2/8 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten 2s. 0d.
Finished bars, 18% tungsten 2s. 9d.
Per lb. net, d/d buyers' works.

Extras—
Rounds and squares, 3 in. and over 4d. lb.
Rounds and squares, under ½ in. to ¼ in. 3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in. 1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in. 3d. lb.
Do., under ½ in. × ¼ in. 1/- lb.
Bevels of approved sizes and sections 6d. lb.
Bars cut to length, 10% extra.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy steel				2	5	0
Bundled steel and shrngs.	1	17	6 to	2	4	0
Mixed iron and steel	2	0	0 to	2	1	6
Heavy cast iron	2	2	6 to	2	4	0
Good machinery	2	8	0 to	2	10	0
Cleveland—						
Heavy steel				2	2	6
Steel turnings				1	10	0
Cast-iron borings				1	3	0
Heavy forge				2	10	0
W.I. piling scrap				2	0	0
Cast-iron scrap	1	19	0 to	2	1	0
Midlands—						
Light cast-iron scrap	1	17	6 to	2	0	0
Heavy wrought iron				2	5	0
Steel turnings, f.o.r.				1	5	6
Scotland—						
Heavy steel	1	18	9 to	2	0	0
Ordinary cast iron				2	5	0
Engineers' turnings				1	11	6
Cast-iron borings				1	13	0
Wrought-iron piling				2	1	3
Heavy machinery	2	8	6 to	2	9	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	31	0	0
Brass	20	0	0
Lead (less usual draft)	12	10	0
Tea lead	10	0	0
Zinc	12	0	0
New aluminium cuttings	74	0	0
Braziery copper	28	0	0
Gunmetal	26	0	0
Hollow pewter	135	0	0
Shaped black pewter	100	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	65/-
Foundry No. 3	62/6
,, at Falkirk	62/3
,, at Glasgow	65/3
Foundry No. 4	61/6
Forge No. 4	61/6
Hematite No. 1, f.o.t.	59/6
Hematite M/Nos., f.o.t.	59/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	68/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	62/-
,, No. 3 fdry.	66/-
Northants forge	58/6
,, fdry. No. 3	62/6
,, fdry. No. 1	65/6
Derbyshire forge	62/-
,, fdry. No. 3	66/-
,, fdry. No. 1	69/-
Scotland—	
Foundry No. 1	67/6
,, No. 3	65/-
Hem. M/Nos. d/d	66/-
Sheffield (d/d district)—	
Derby forge	59/6
,, fdry. No. 3	63/6
Lincs forge	59/6
,, fdry. No. 3	63/6
E.C. hematite	73/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/-
Clyde, No. 3	82/-
Monkland, No. 3	82/-
Summerlee, No. 3	82/-
Eglinton, No. 3	82/-
Gartsherrie, No. 3	82/-
Shotts, No. 3	82/-

FINISHED IRON AND STEEL.

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	0	0 to	9	15	0
Nut and bolt iron	6	15	0 to	7	10	0
Hoops	10	10	0 to	12	0	0
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 to	12	0	0
Bolts and nuts, ¾ in. × 4 in.				13	0	0
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.				8	5	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ⅜ in. (Untested)	6	17	6 & up.			
Flats—8 in. wide and over				8	12	6
,, under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	0	0
Hoops (Staffs)	9	10	0 & up.			
Black sheets, 24g. (10-t. lots)				10	0	0
Galv. cor. shts.	,,			12	10	0
Galv. flat shts.	,,			13	0	0
Galv. fencing wire, 8g. plain				14	0	0
Billets, soft	5	0	0 to	5	12	6
Billets, hard	6	12	6 to	7	2	6
Sheet bars	4	15	0 to	5	5	0
Tin bars				4	15	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	11d.
Sheet to 10 w.g.	12d.
Wire	12½d.
Rods	11d.
Tubes	15½d.
Castings	13d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1¼ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	16.34
No. 2 foundry, Valley	15.50
No. 2 foundry, Birm.	12.00
Basic	16.89
Bessemer	17.89
Malleable	17.39
Grey forge	17.39
Ferro-mang. 80%, seaboard	68.00
O.-h. rails, h'y, at mill	40.00
Billets	26.00
Sheet bars	26.00
Wire rods	35.00
	Cents.
Iron bars, Phila.	1.86
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Steel hoops	1.55
Sheets, black, No. 24	2.10
Sheets, galv., No. 24	2.70
Wire nails	1.85
Plain wire	2.10
Barbed wire, galv.	2.35
Tinplates, 100-lb. box	$4.25

COKE (at ovens).

Welsh foundry	20/- to 22/6
,, furnace	15/- to 15/6
Durham and Northumberland—	
,, foundry	21/- to 25/-
,, furnace	13/3
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	17/3 to 17/6
,,	28×20 ,,	34/6 to 35/-
,,	20×10 ,,	24/9 to 25/3
,,	18⅞×14 ,,	18/- to 18/3
C.W.	20×14 ,,	15/9 to 16/6
,,	28×20 ,,	33/3 to 33/6
,,	20×10 ,,	22/9
,,	18⅞×14 ,,	16/6

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0 to	£7	0	0
Bars-hammered, basis	£16	0	0 to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	0	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£30	0	0 to	£31	0	0
Faggot steel	£18	0	0 to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0 to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
July	6 ..	38	15	0	dec.	3/9
,,	7 ..	38	13	9	,,	1/3
,,	10 ..	38	18	9	inc.	5/–
,,	11 ..	37	16	3	dec.	22/6
,,	12 ..	38	11	3	inc.	15/–

Electrolytic Copper.

		£	s.	d.		
July	6 ..	42	10	0	No change	
,,	7 ..	42	0	0	dec.	10/–
,,	10 ..	42	5	0	inc.	5/–
,,	11 ..	41	15	0	dec.	10/–
,,	12 ..	42	0	0	inc.	5/–

Standard Tin (cash).

		£	s.	d.		
July	6 ..	223	5	0	dec.	42/6
,,	7 ..	221	10	0	,,	35/–
,,	10 ..	215	15	0	,,	115/–
,,	11 ..	211	10	0	,,	85/–
,,	12 ..	217	15	0	inc.	125/–

Tin (English ingots).

		£	s.	d.		
July	6 ..	224	10	0	dec.	45/–
,,	7 ..	222	15	0	,,	35/–
,,	10 ..	217	5	0	,,	110/–
,,	11 ..	212	15	0	,,	90/–
,,	12 ..	219	0	0	inc.	125/–

Spelter (ordinary).

		£	s.	d.		
July	6 ..	18	5	0	inc.	5/–
,,	7 ..	18	10	0	,,	5/–
,,	10 ..	18	11	3	,,	1/3
,,	11 ..	17	17	6	dec.	13/9
,,	12 ..	18	3	9	inc.	6/3

Spelter (Electro, 99.9 per cent.).

		£	s.	d.		
July	6 ..	20	10	0	No change	
,,	7 ..	20	15	0	inc.	5/–
,,	10 ..	20	15	0	No change	
,,	11 ..	20	5	0	dec.	10/–
,,	12 ..	20	10	0	inc.	5/–

Zinc Sheets (English).

		£	s.	d.		
July	6 ..	25	10	0	inc.	5/–
,,	7 ..	26	0	0	,,	10/–
,,	10 ..	26	0	0	No change	
,,	11 ..	26	0	0	,,	,,
,,	12 ..	26	0	0	,,	,,

Lead (English).

		£	s.	d.		
July	6 ..	15	0	0	No change	
,,	7 ..	15	0	0	,,	,,
,,	10 ..	15	0	0	,,	,,
,,	11 ..	14	15	0	dec.	5/–
,,	12 ..	15	0	0	inc.	5/–

AVERAGE MONTHLY PRICES OF WEST COAST HEMATITE MIXED NUMBERS DELIVERED SHEFFIELD.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1894	45 3	45 3	45 1½	45 1	43 11	43 11	43 9½	44 2	44 7½	43 7	43 5	43 3	44 3½
1895	42 8	42 5½	42 6	42 10	43 10	43 7½	44 10	45 11	49 11	48 9	47 7½	47 7½	45 2½
1896	47 0	48 9	48 9	48 2½	47 3	47 3	46 10	46 10	47 2	48 5	50 7	50 6	48 1½
1897	51 2	49 10	48 5	47 4	47 9½	48 6	47 0	47 3	47 3	47 0	48 3½	47 11	48 2
1898	48 9	48 10	49 4	49 8½	50 10	50 3½	51 0	52 5	53 11	55 8	57 3	56 10	52 1½
1899	59 1	59 9	57 7	59 6	64 7	70 10½	76 7½	72 2	74 3	75 0	78 1½	73 3	68 5
1900	75 3½	76 10	79 10	84 6	81 4	79 1½	83 4	81 5	79 11	76 10	77 8½	68 4	78 8
1901	60 2	59 0	57 9½	57 6½	57 8	57 4½	57 8	61 0	60 0½	59 9	58 7½	56 7	58 7½
1902	56 1	57 9½	59 3½	59 9	59 10½	60 0	60 0	60 8½	61 5	61 2	59 3	59 0	59 6
1903	58 5	58 8	61 1	59 5	57 10	57 3	56 7	56 3	55 9	54 8	52 4	52 4	56 8½
1904	52 8½	53 1	53 7	54 9	54 2	53 2½	52 9	52 5	52 2½	52 7	53 1	55 11½	53 5½
1905	57 9½	56 9	58 1	58 2	56 4	55 8	55 5½	56 7	61 0	68 0	69 9	70 11½	60 5½
1906	70 4½	65 2½	63 4½	63 9	64 5	64 6	64 1	66 2½	67 3	69 4½	72 4½	78 8½	67 5
1907	77 9	72 11	71 10	73 9	79 9½	76 9	77 9	78 4	75 11	72 9½	68 6	66 7	74 4
1908	62 7	59 1	61 6½	61 6½	61 4	59 1	57 9½	56 11	60 2	59 2	58 5½	57 7	59 7½
1909	51 4	56 5	55 3	56 1	56 4	57 0	56 8	58 0	61 0	61 1½	60 7½	61 4	58 1½
1910	64 0½	64 3½	66 10½	67 6½	66 2½	65 4	64 4½	65 6½	65 2	64 10½	64 6	65 6	65 4½
1911	66 9	66 1	64 10	63 1	62 1	62 0	61 2	62 2	62 1	61 1	61 10	64 0	63 1
1912	67 0	67 0	67 0	69 3	71 9½	72 11	75 9½	79 1½	82 2½	85 0	85 3½	86 6	75 9½
1913	86 6	86 6	86 3	85 0	83 6½	80 10½	78 1	76 10½	72 6	71 0	68 0	65 3	78 4½
1914	64 6	65 4½	65 6	64 11½	64 2½	64 0	64 0	68 11½	74 6½	71 0	65 4½	69 9½	66 10½
1915	78 9	100 6	103 1	113 6	111 9	114 0	116 3	115 2½	113 8½	121 1½	131 9½	139 6½	113 3
1916	135 0	135 0	133 4	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	129 2½
1917	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1918	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1919	127 6	127 6	127 6	127 6	180 6	184 3	195 4½	204 6	204 6	204 6	204 6	204 6	174 7
1920	224 9	235 0	245 0	275 0	290 0	295 0	295 0	295 0	295 0	295 0	295 0	280 0	284 11½
1921	263 4	228 4	180 0	180 0	180 0	160 0	160 0	157 6	142 0	128 6	121 0	115 6	167 9½
1922	125 0	117 6	115 0	115 0	115 0	115 0	113 1½	104 0	105 0	105 0	106 3	110 0	112 1
1923	109 0½	116 5½	133 11½	138 3½	134 2	125 0	115 7½	111 9	110 0	110 0	113 11	115 0	119 8½
1924	115 0	115 0	114 4½	112 6	112 6	112 6	111 0	110 0	110 0	105 4½	102 6	102 6	110 3½
1925	102 6	102 6	100 0	98 6	97 6	95 1½	92 6	90 6	88 3	87 0	88 1½	88 9½	94 3½
1926	90 1½	90 0	89 8½	89 0	89 0	89 0	90 2½	91 9	94 0	97 2½	*	*	91 0
1927	95 4½	95 6	96 6	95 6	95 3	94 0	92 10½	91 6	90 6	90 6	90 6	89 6	93 1½
1928	85 0	85 3	85 5	85 0	85 3	84 9	84 0	83 9	84 0	84 0	83 1	82 6	84 4
1929	82 10½	83 6	85 0	86 9	87 0	87 0	87 3	87 2½	87 6	89 6	89 6	89 10½	86 11
1930	91 6	91 6	91 6	90 0	89 7½	88 0	87 7½	86 6	86 6	86 6	86 6	86 6	88 0½
1931	86 6	84 6	84 6	84 6	84 6	82 6	82 6	81 6	81 6	83 6	83 6	83 6	83 7
1932	83 6	83 6	83 6	83 6	83 6	83 6	83 6	83 6	83 6	83 6	83 6	83 6	83 6
1933	83 6	83 6	83 6	83 6	83 6	83 6	—	—	—	—	—	—	—

* No prices available.

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